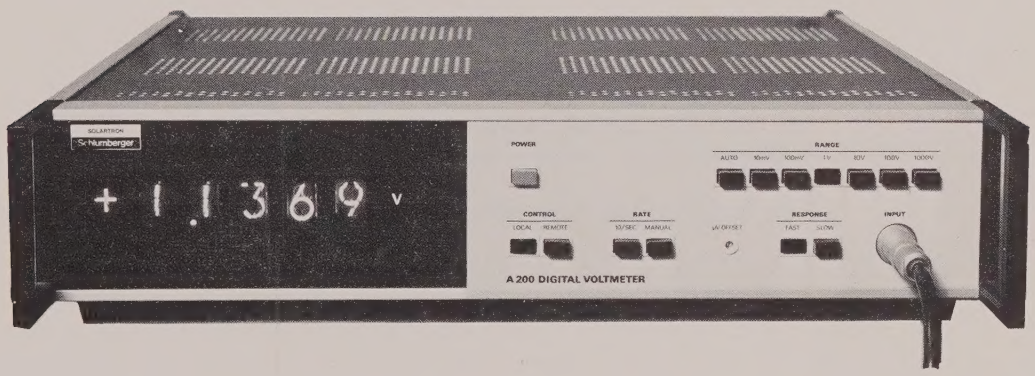
DIGITAL VOLTMETERS

A200 A203 A205
A220 A223 A225
A227

FAN OUT UNIT A204

DIGITAL VOLTMETERS

A200 A203 A205 A220 A223 A225 A227



Part No. A2000221

Date of Issue : December 1974

Schlumberger

THE SOLARTRON ELECTRONIC GROUP LIMITED
FARNBOROUGH HAMPSHIRE ENGLAND GU14 7PW
TEL: FARNBOROUGH 44433 (STD 0252)
CABLES: SOLARTRON FARNBOROUGH HANTS
TELEX: 858245 SOLARTRON FARNBOROUGH

TECHNICAL MANUAL

19©73

Printed in England by The Solartron Electronic Group Ltd.

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_11200

INTRODUCTION

Your new digital voltmeter (dvm) is the latest in a series of sophisticated and advanced instruments. Solartron design experience has made available an accurate and sensitive range of voltmeters which, when fitted with a fan out unit, are fully programmable by remote commands.

The functional control layout and clear, unambiguous display make this a simple to use dvm whilst the AC and Ohms options make the basic instrument even more versatile.

This manual contains all the necessary information on how to operate your dvm; read it carefully so that you can use the dvm to its full capability.

The Display

Some instruments use a type of display different from those illustrated in this manual. An example of an instrument with the alternative display is shown overleaf.

All information given in this manual applies to instruments with either display.

A Type A223 using a 7 Bar Neon type of display.

As well as the shape of the numerals, the appearance and positioning of the annunciators have also changed.

The following are in column to the extreme left of the display.

WAIT	Indicates an invalid display. A measurement is true when this indicator is extinguished.
O/L	Overload, in conjunction with a display of 19999.
~	AC value displayed.
REMOTE	The instrument is under remote control.

The polarity signs, + and −, lie between the annunciator column and the numerals. The units annunciators are to the right of the numerals.

CONTENTS

INTRODUCTION

SECTION 1 CONTROLS

- A200
- A203/A205
- A220/A227
- A223/A225
- REAR PANEL

SECTION 2 TECHNICAL SPECIFICATION

SECTION 3 OPERATING INSTRUCTIONS

- DC VOLTAGE MEASUREMENT
- AC VOLTAGE MEASUREMENT
- RESISTANCE MEASUREMENT
- CURRENT MEASUREMENT

SECTION 4 MEASUREMENT TECHNIQUES

SECTION 5 DATA SYSTEMS USE

SECTION 6 PRINCIPLE OF OPERATION

SECTION 7 CIRCUIT DESCRIPTION & SERVICING INFORMATION

SECTION 8 TEST SPECIFICATION
CALIBRATION PROCEDURE
TESTING A204 FAN OUT

- APPENDIX, TEST GEAR

SECTION 9 COMPONENT PARTS LIST

A220

A227

Indicator

Displays units (mV or V), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement when a MANUAL sample has been initiated whilst the voltmeter is in the SLOW RESPONSE mode.

WAIT is extinguished when the display is updated.

REMOTE is displayed when the voltmeter is under remote control.

POWER

A push for ON - push for OFF switch for applying mains power to the voltmeter.

A227 only; AUTO RANGE button here

RANGE

A220
Five mutually exclusive push button switches for selecting the **100mV,1V,10V,100V or 1000V DC ranges.**

A227
Six mutually exclusive push button switches for selecting:

1) AUTO: For automatic selection of optimum range.

2) 100mV,1V,10V,100V or 1000V DC ranges.

On both the A220 and A227, if two or more buttons are pressed the least sensitive range is selected.
If no buttons are pressed the 1000V range is selected.

RESPONSE

Two mutually exclusive push-button switches for selecting

FAST: For unfiltered DC measurements.

SLOW: For filtered DC measurements. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/octave (20dB/decade).

Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

⊙ Overload symbol flashes and the display shows 19999 for inputs which exceed 19999.

Display

Numericals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

CONTROL

Two mutually exclusive push-button switches for selecting

LOCAL: For control of the voltmeter from the front panel controls. When a Fan Out Unit is fitted and REMOTE is electrically commanded, LOCAL is overridden, REMOTE is displayed and the only effective front panel control is POWER.

REMOTE: For control of the voltmeter by remote electric commands via the Fan Out Unit. When REMOTE is selected REMOTE is displayed.

If no Fan Out Unit is fitted the instrument remains in the LOCAL CONTROL mode.

RATE

Two mutually exclusive push-button switches for selecting

10/SEC: For automatic updating of the display every 100ms.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

If SLOW RESPONSE is selected the display is updated 1 second after pressing the button. (During this time WAIT is displayed).

Both of these controls are effective even if REMOTE has been selected on the front panel CONTROL buttons, provided REMOTE has not been externally commanded via a Fan Out Unit.

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts) when making measurements on the 100mV range. Provides not less than ± 100μV offset capability.

INPUT

'Snap-in' connector to which the signal is applied via a screened cable.

To remove the connector, pull the skirt of the connector and not the cable.

A223

(ac mean sensing)

A225

(rms sensing)

Indicator

Displays units (mV, V and kΩ), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement.

1) When a MANUAL sample has been initiated whilst the voltmeter is in the SLOW RESPONSE mode.

2) When a MANUAL sample has been initiated whilst the voltmeter is in the AC mode.

WAIT is extinguished when the display is updated.

REMOTE is displayed when the voltmeter is under remote control.

POWER

A push for ON - push for OFF switch for applying mains power to the voltmeter.

MODE

Three mutually exclusive push-button switches for selecting either DC, AC or Ω (ohms) measurements. As a safety precaution, if two, all or none of the buttons are pressed DC MODE is selected. Also, if all the buttons are released DC MODE is selected.

RANGE

Five mutually exclusive push-button switches for selecting

1) **100mV, 1V, 10V, 100V or 1000V DC ranges.**

2) **100mV, 1V, 10V, 100V or 1000V AC ranges.**

3) **1kΩ, 10kΩ, 100kΩ, 1MΩ or 100MΩ resistance ranges.**

If two or more buttons are pressed

If two or more buttons are pressed the least sensitive range is selected. If no buttons are pressed the 1000V or 10MΩ range is selected.

RESPONSE

Two mutually exclusive push-button switches for selecting

FAST: 1) For unfiltered DC measurements.

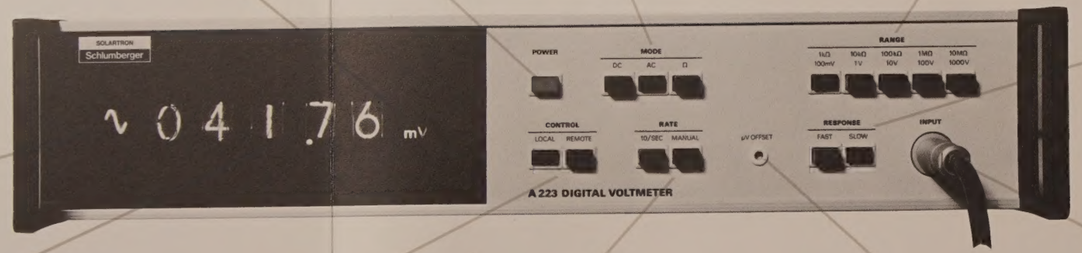
2) For unfiltered resistance measurements.

3) For measurement of AC signals with frequency components ⩾ 100Hz. If 10/SEC RATE is selected wait 1 second after application of the signal before reading the display.

SLOW: 1) For filtered DC measurements. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/octave (20dB/decade).

2) For filtered resistance measurements using the same filter as for dc. Not recommended when AUTO ranging for resistances above 50kΩ.

3) For extended AC low frequency performance (down to 20Hz). If 10/SEC RATE is selected wait 5 seconds after application of the signal before reading the display. If MANUAL is selected wait 4 seconds after application of the signal before pressing the button.



Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

∿ Sine wave symbol displayed in the AC mode.

Overload symbol flashes and the display shows 19999 for inputs which exceed 19999.

Display

Numericals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

CONTROL

Two mutually exclusive push-button switches for selecting

LOCAL: For control of the voltmeter from the front panel controls. When a Fan Out Unit is fitted and REMOTE is electrically commanded, LOCAL is overridden, REMOTE is displayed and the only effective front panel control is POWER.

REMOTE: For control of the voltmeter by remote electric commands via the Fan Out Unit. When REMOTE is selected REMOTE is displayed.

If no Fan Out Unit is fitted the instrument remains in the LOCAL CONTROL mode.

RATE

Two mutually exclusive push-button switches for selecting

10/SEC: For automatic updating of the display every 100ms.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

If AC and/or SLOW RESPONSE is selected the display is updated 1 second after pressing the button. (During this time WAIT is displayed).

Both of these controls are effective even if REMOTE has been selected on the front panel CONTROL buttons, provided REMOTE has not been externally commanded via a Fan Out Unit.

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts) when making measurements on the 100mV range. Provides not less than ± 100μV offset capability.

INPUT

'Snap-in' connector to which the signal is applied via a screened cable.

To remove the connector, pull the skirt of the connector and not the cable.

Rear Panel
[all units]

Rear Input

Position where rear input socket can be fitted

Fuse Holder

98 to 128V : 500mA/750mA* SLO-BLO fuse
195 to 255V : 250mA/300mA* SLO-BLO fuse

* As indicated on MAINS SELECTOR PLATES

Mains Selector Switches

Mains voltage selection is effected by positioning the switches so that the appropriate mains selector plate can be screwed on.

There are four possible ranges of mains input:-

1) 98 - 115V 2) 220 - 255V	50 - 60Hz	Plate 1
3) 110 - 128V 4) 195 - 230V	50 - 60Hz	Plate 2

Blanking Plate

Removed for fan out unit installation.

CONTROLS

The push button controls of this series of voltmeters are arranged in six groups in accordance with the six decisions which have to be made for any measurement.

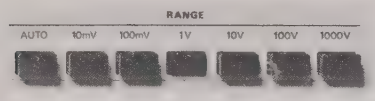
1. POWER

This heavy duty mains switch operates with a push on - push off action. The numerical display is always illuminated whenever the instrument is switched on and no separate warning is required. This is the only button which cannot be remotely controlled, but the voltmeter can, of course, be remotely switched ON and OFF by interruption of the mains supply.

2. MODE

The second group of controls select either DC, AC or Ohms. These buttons are mutually exclusive and pressing any one automatically releases the one previously selected. In the event of a user forcing in more than one of these buttons at the same time (misuse) the voltmeter automatically reverts to the DC mode as a safety precaution. DC only instruments (A200, A220, A227) have no mode switches.

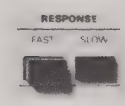
3. RANGE



This row of buttons selects the sensitivity setting. Again, pressing one button releases any previously selected in the group. There is one button for each range and on the A200, A203, A205 and A227 there is also an auto range control. Pressing the AUTO button causes the voltmeter to automatically select the correct range for any input voltage from 1μV to 1000V. Unless there is a particular reason for pre-selecting a fixed range, the use of auto range is recommended - there is no reduction of accuracy, noise rejection or input resistance and in the event of accidental overload, the voltmeter automatically moves to the appropriate range. If more than one range button is pushed, the least sensitive will be selected.

A word of caution: there are more dc ranges than ac or ohms ranges and the 10mV button, although applicable only to dc, could be pressed when AC or Ω has been selected. The voltmeter does not respond to this invalid command and selects instead, the 100mV or 1kΩ range. The units display and decimal point setting will always be correct. As it is normal to think in decimal terms, the legend which identifies each range follows a 1, 10, 100 sequence. However, there is a 99% overrange capability on all ranges. For example, the full scale value of the 1V range is, in fact, 1.9999V. There is no degradation of the performance specification in this upper part of the scale. On voltage measurement however, the maximum recommended input is 1200V dc or 1.2kV peak (850V rms)

4. RESPONSE



As far as dc and ohms measurements are concerned, these controls should be regarded as a luxury and not required in all but the most exceptional circumstances. In general they should be left in the FAST mode. For dc and resistance the SLOW button selects an active low pass filter to reduce the effects of any noise interference. However, because the voltmeter is an integrating type (with mains locked integration on A200, A203 and A205), it inherently rejects mains frequency interference and its harmonics without the filter. SLOW is therefore seldom required. In doubtful cases the effect of the control should be observed: if any change in the reading results from the use of the filter this must be as a result of noise being rejected and SLOW should be chosen in this instance.

The use of a filter introduces long time constants into an otherwise fast acting instrument, and the user should therefore exploit the inherent noise rejecting properties of this instrument and avoid unnecessary use of the filter.

For ac measurement this control has a different purpose. Inherent in the design of an ac measurement system is the compromise between response time and low frequency performance. Therefore, to cater for a wide variety of applications this choice is left to the user. With AC FAST, the response time to 0.1% is 1 second.

If the input signal contains frequency components below 100Hz the reading will fluctuate under the influence of the low frequency. With AC SLOW, the response time is increased to 5 seconds, but accurate readings can be taken on signals which include frequency components down to 20Hz. The upper frequency limit of measurement is unaffected by FAST/SLOW selection.

5. RATE

A feature of these voltmeters is that they operate on a continuous basis, always responding to the applied signal. Whenever they are switched on they are making 10 measurements each second, although the result of every measurement will be displayed only when the 10/SEC button is pressed. When MANUAL is selected the voltmeter still makes 10 measurements each second, but the display is updated only upon pressing the button.

As an added precaution, the auto range circuitry continues to protect the instrument when MANUAL and AUTO have been selected. Even though the display retains the value applicable when the last sample was called for, in this mode of operation the instrument may in fact have moved to a different range under the influence of a change in the input signal. However, the information on the display still remains applicable to the last command measurement.

6. CONTROL

As indicated by the legend these controls affect the changeover from manual (front panel) to remote control. When LOCAL is selected the REMOTE button is released and any remote electrical commands (except a call for REMOTE) are ignored.

The LOCAL/REMOTE buttons are fitted regardless of whether or not Fan-Out Unit A204 has been installed. If there is no fan-out unit and the REMOTE button is operated, local control is retained. With a fan-out unit, when REMOTE is selected control of MODE (DC, AC and Ω), RANGE (including AUTO range) and RESPONSE (FAST/SLOW) is possible only by external electrical commands via the fan-out unit. Other than POWER the only buttons still operative are those for RATE so that front panel control is still available to command either 10/SEC or single sample. In addition, with 10/SEC released, a measurement may be remotely initiated by electrical pulse or contact closure.

A feature made available by the CONTROL switches is that users can remotely command both repetitive or single sample. This is achieved in the following way:-

Select REMOTE and 10/SEC by means of the front panel switches.

For "single shot" sample call REMOTE electrically via the fan-out and initiate each sample by either contact closure or pulse application via the fan-out unit.

For 10/SEC sampling do not electrically command REMOTE.

In both cases control of the remaining functions is by remote command via the fan-out unit.

Front Panel Lock-Out

Not apparent from the front panel is an extra facility known as Front Panel Lock-Out. Under the control of an external electrical command (command REMOTE) applied via Fan-Out Unit A204, the action of all front panel controls can be inhibited with the exception of POWER. In this condition all control must be by electrical command and the LOCAL button cannot be used to regain manual control. The user is reminded of this condition by the word REMOTE being displayed.

This feature prevents unauthorised use when the voltmeter is committed within a system or, with suitable programming of the REMOTE command, enables a test sequence to include both automatic and operator control.

INPUT CONNECTOR

The input connector simply pushes into the front panel socket with a "snap-in" action. This cannot be released by pulling on the cable, but separation occurs only when the skirt of the connector is pulled away from the panel.

The "snap-in" connector has been chosen to permit the use of a long input lead which may be required when the voltmeter is rack mounted. Experience with push-on 4mm connectors has shown that they tend to fall off under the weight of a long lead.

The skirt of the chosen connector acts as an isothermal chamber preventing temperature differentials which would give rise to errors caused by thermal emf's. The standard input lead provides connection for signal high (red) and signal low (black). It will be seen that the connector contains five pins and users wishing to use a three terminal driven guard, input configuration should use input lead EX 3183 available as an optional extra. (A guide to three terminal measurement in "noisy" conditions can be obtained from the Solartron publication "Digital Voltmeters and Interference" which is free on request). This same lead is also used for a 4 terminal ohms measurement which is described later in this manual. The input to the voltmeter is completely isolated from earth and from all of the programming inputs and digital outputs.

Rear Input

This is fitted only on request and is wired in parallel with the normal front input. The input capacitance is increased by 80pF. The back panel includes a cut-out for the later addition of a rear input, and users installing their own rear connector are reminded that the use of p.t.f.e. coated wire is necessary to maintain the isolation characteristics.

μV OFFSET

A200, A203 and A205 include a sophisticated chopper input amplifier to maintain very high integrity μV measurement. The stability of the input stage is such that, provided 90 minutes initial warm up is allowed, the drift with time is less than 1μV per week on the 10mV range; initial warm up on all other range is 60 minutes.

External conductors, however, may introduce thermal errors and the μV OFFSET control can be used to offset such effects. The range of offset is $\pm$ 15μV.

DISPLAY

The display area is covered by a tinted screen laminated with a circularly polarised membrane to inhibit stray light or reflected light from the indicator tubes. The front surface is lightly frosted to eliminate surface reflection from overhead lights or light coloured garments worn by the user. Very slight de-focusing results from this frosting.

The display information is updated either ten times per second or on manual command as described earlier.

From left to right the information is:-

a) $\pm$ **Automatic polarity indication.** The polarity is that of the red lead with respect to the black.

b) $\sim$ This sign is displayed when AC MODE is selected.

c) Overrange indication is given by a flashing symbol when the input exceeds 19999. The user is not required to remember the full scale of the instrument.

d) **Numerical Indication.** Cold cathode neon number tubes, which have been proved to have extremely long life, are used to present the result of measurement.

e) **Decimal Point.** This is positioned automatically in conjunction with the units display.

f) **Units.** V, mV and kΩ. Display of the units is automatic and appropriate to the sensitivity and mode. Units, decimal point and numerical information are updated only as a result of digitise command as directed by the RATE control.

g) **Wait.** When the user selects a slow mode of operation, for example SLOW and AUTO range, an appreciable period of time may elapse before the new measurement is complete. During this time the result of the previous measurement is retained by the display. As a precaution against the wrong value being noted the legend WAIT lights up and is only extinguished when the new result is displayed.

h) **Remote.** Indication that the instrument is under either remote control or front panel lock-out. Only applicable when fan-out A204 is fitted.

Rack Mounting

The overall dimensions conform to international standards for rack mounting. The instrument can be rack mounted within its case with no additional protection required. Users who wish to remove the top, bottom and side covers can do so by undoing the two screws which secure the side covers and sliding out all the covers starting with the sides. For rack mounting the combination handle/ears should be substituted for the normal handles. These combination rack mounting handles are supplied in the accessory pack with each voltmeter.

SECTION 2 Technical Specification

DC RANGES

Range	Sensitivity	Full Scale	Input Resistance
10mV*	1μV	19.999mV	> 1000MΩ
100mV	10μV	199.99mV	> 10000MΩ
1V	100μV	1.9999V	> 10000MΩ
10V	1mV	19.999V	> 10000MΩ
100V	10mV	199.99V	10MΩ ± 0.1%
1000V	100mV	1200.0V**	10MΩ ± 0.1%

* A200/A203/A205 only.

** 1000V range: Although full scale remains 1999.9V it is advisable not to exceed the given value.

AC RANGES (A203, A205, A223, A225)

Range	Sensitivity	Full Scale	Input Impedance*
100mV	10μV	199.99mV	10MΩ/< 150pF
1V	100μV	1.9999V	10MΩ/< 150pF
10V	1mV	19.999V	1MΩ/< 100pF
100V	10mV	199.99V	1MΩ/< 100pF
1000V	100mV	1000V**	1MΩ/< 100pF

*Input capacitance measured between Hi and Lo at input socket excluding input cable. Capacitance is increased by 80pF if rear input socket is fitted.

** 1000V Range: Although full scale remains 1999.9V 1.2kV peak (850V rms) must not be exceeded.

OHMS RANGES (A203, A205, A223, A225)

Range	Sensitivity	Full Scale	Test Current
1kΩ	100mΩ	1.9999kΩ	600μA
10kΩ	1Ω	19.999kΩ	600μA
100kΩ	10Ω	199.99kΩ	60μA
1MΩ	100Ω	1999.9kΩ	0.6μA
10MΩ	1kΩ	19999.kΩ	0.6μA

REMOTE RANGE: The remote selection of any range may be commanded via optional Fan-Out unit A204.

OVERLOAD: An overload symbol flashes and the display shows 19999 for inputs which exceed 19999.

AUTO RANGE: Auto is available on A200, A203, A205 and A227 only. Operates on all ranges.

AC SCALING:

(A203, A223) The instrument senses the mean value of the ac component and displays the rms value - assuming a sine wave signal.

(A205, A225) The instrument senses the true rms value of the ac component regardless of waveshape.

Coefficient of reading 0 - 50°C. 10Hz to 100kHz A205/A225

All ranges

± 0.015% of reading

± 0.001% of full scale

RESISTANCE RANGES

Zero Drift 0 - 50°C

Range	A203/A205	A223/A225
1kΩ	0.001% of full scale per °C	0.001% of full scale per °C
10kΩ	0.0001% of full scale per °C	0.0001% of full scale per °C
100kΩ	0.0001% of full scale per °C	0.0001% of full scale per °C
1MΩ	0.001% of full scale per °C	0.001% of full scale per °C
10MΩ	0.001% of full scale per °C	0.001% of full scale per °C

Coefficient of Reading 0 - 50°C

Range	A203/A205	A223/A225
1kΩ	< ± 0.002% per °C	< ± 0.004% per °C
10kΩ	< ± 0.002% per °C	< ± 0.004% per °C
100kΩ	< ± 0.002% per °C	< ± 0.004% per °C
1MΩ	< ± 0.002% per °C	< ± 0.004% per °C
10MΩ	< ± 0.002% per °C	< ± 0.004% per °C

CREST FACTOR A205/A225 only

4:1 at full scale up to 20kHz

INPUT CHARACTERISTICS

Input voltage should not exceed 100V whilst changing mode.

DC RANGES

Input Current: $< 10^{-10}$ A

Overload

10mV, 100mV, 1V, 10V Ranges

Max. permitted input: 200V continuous (1200V for up to 200ms)

100V, 1000V Ranges

Max. permitted input: 1200V

Input resistance: 10MΩ ± 0.1%

AC RANGES

Overload

100mV, 1V Ranges

Max. permitted input: 300V peak (1200V peak for up to 2s) Note. On models A205 and A225 the input voltage/frequency must not exceed 6 x 10^6 VHz

10V, 100V, 1000V Ranges

Max. permitted input: 1.2kV peak (850V rms)

RESISTANCE RANGES

Overload

All ranges

Max. permitted input 300V. peak

ISOLATION IMPEDANCE

Guard to Chassis: $> 10^{10}\Omega$ and < 500pF

RESPONSE TIMES

Auto Range Response Time

DC FAST: Shall have selected the correct range within 0.7s.

DC SLOW: Shall have selected the correct range within 6s.

AC FAST: Shall have selected the correct range within 6s, A203/A223 or 7s, A205.

AC SLOW: Not available. Voltmeter reverts to AC, FAST AUTO range.

Ω FAST Shall have selected the correct range within 0.7s for resistances $\leq 1M\Omega$

Ω SLOW As DC SLOW for values $\leq 50k\Omega$
Not recommended for values $> 50k\Omega$

INTERFERENCE REJECTION – SERIES MODE

The ratio of the peak interference at the input terminals to one digit reading error. These figures apply providing that the applied signal plus the noise does not exceed 120% of full scale, on each range (but note the maximum permissible input on the 1000V range).

DC FAST

A200/A203/A205: $>$ 70dB at mains frequency (Nominal 50Hz ± 2%)

A220/A223/A225/A227: $>$ 36dB at 50Hz $\pm$ 1%

DC SLOW

A low pass active filter increases the above figures by 30dB at 50Hz increasing at 6dB/Octave.

INTERFERENCE REJECTION – COMMON MODE

The ratio of the peak interference, applied between signal source and instrument ground (chassis), to the reading error, when there is 1kΩ unbalance between the high and low signal paths.

The maximum common mode voltage must not exceed 500V dc or peak ac.

DC RANGES With Guard connected to Lo in the standard input cable (2 terminal measurement):

	A200/A203/A205	A220/A223/A225/A227
DC	> 140dB	> 140dB
50Hz FAST	> 145dB	> 110dB
50Hz SLOW	> 174dB	> 155dB

AC RANGES With guard connected to Lo in the standard input cable (2 terminal measurement)

	A203/A205	A223/A225
DC	> 140dB	> 140dB
50Hz FAST	> 40dB	> 40dB
50Hz SLOW	> 40dB	> 40dB

DC RANGES With Guard connected to the source of common mode (3 terminal measurement).

	A200/A203/A205	A220/A223/A225/A227
DC	> 150dB	> 150dB
50Hz FAST	> 160dB	> 125dB
50Hz SLOW	> 174dB	> 155dB

AC RANGES With Guard connected to the source of common mode (3 terminal measurement).

	A203/A205	A223/A225
DC	> 150dB	> 150dB
50Hz FAST	> 60dB	> 60dB
50Hz SLOW	> 60dB	> 60dB

TEMPERATURE RANGE

Operation: This specification applies for operation in the ambient ranges 0 - 40°C (A220/A223/A225/A227) and 0 - 55°C (A200/A203/A205)

Storage: The instrument can be stored at ambients between -30°C and +70°C.

MAINS SUPPLY

This specification relates to supplies of 117/234V + 10% -15%, 50Hz or 60Hz. Modification is necessary to achieve full interference rejection at 60Hz.

Consumption: 40VA.

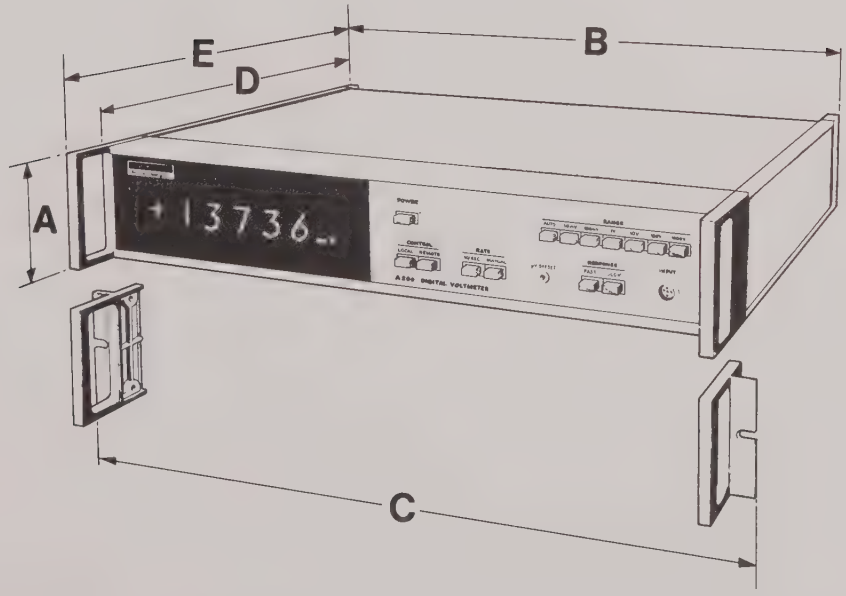
Fan Out Unit A204

Outputs:	TTL Compatible. High (Logic 1) + 2.4V to + 6V from a 6kΩ source Low (Logic 0) – 0.5V to + 0.5V at 10mA 'sink'.
Inputs:	TTL Compatible. High (Logic 1) + 2.4V to + 6V or open circuit. Low (Logic 0) – 0.5V to + 0.5V at 5mA 'sink'.

Pulse Sample

Pulse Amplitude:	+3V to +8V
Duration:	$>10\mu s$.
Input Impedance:	$>10k\Omega$

DIMENSIONS



A = 88mm (3.46in)
B = 442mm (17.40in)
C = 482mm (18.98in)
D = 322.58mm (12.70in) Without side covers.
E = 362.58mm (14.28in) Without side covers.

Weight

7kg (15½lb) (Dependent upon model)

ACCESSORIES

Each voltmeter is supplied with the following:-

	Solartron Part No.
Signal Input Lead with 4mm Plug Terminations	A2000168
Test Prod (Red)	351901020
Test Prod (Black)	351901010
Croc. Clip (Red)	355900670
Croc. Clip (Black)	355900660
Fuse 500mA SLO–BLO (2 off)	306103060
Fuse 250mA SLO–BLO (2 off)	306103050
Handle, Rack Mounting	A2000111

Each fan out unit is supplied with the following:-

50 Way Plug (BICC MS50 RN–BR118) (1 off)	354002340
Pins (BICC RM20M – 12 – D29) (50 off)	354001610

SECTION 3 Operating Instructions

PRELIMINARY ADJUSTMENTS

Check that the instrument is set to operate from the local mains supply.

Check that the correct fuse is fitted.

250mA/300mA* SLO-BLO for mains voltage between 195V and 255V

500mA/750mA* SLO-BLO for mains voltage between 98V and 128V

Connect a suitable plug to the mains lead:-

BROWN	-	LINE
BLUE	-	NEUTRAL
GREEN/YELLOW	-	EARTH

* As indicated on Mains Selector Plate

DC VOLTAGE MEASUREMENT

Although the maximum dc input voltages that may safely be applied to the instrument are:

i) 1200V on the 1000V and 100V ranges

ii) 200V on the 10V, 1V, 100mV and 10mV ranges

the 10V, 1V, 100mV and 10mV ranges will withstand 1200V for up to 200ms. Thus, for AUTO range purposes, the range of input voltages can be from 0 to 1200V.

1. Switch POWER on.

2. Select LOCAL or REMOTE. If the instrument is fitted with a fan out unit and REMOTE is selected see the section of this manual which covers remote operation for a list and description of the remote control facilities. If LOCAL is selected, read on from step 3.

3. Choose an appropriate range or AUTO range.

4. If the instrument is an A203 or A223 press the DC MODE push-button.

5. Connect the input lead to the unknown voltage source, red to signal high and black to signal low.

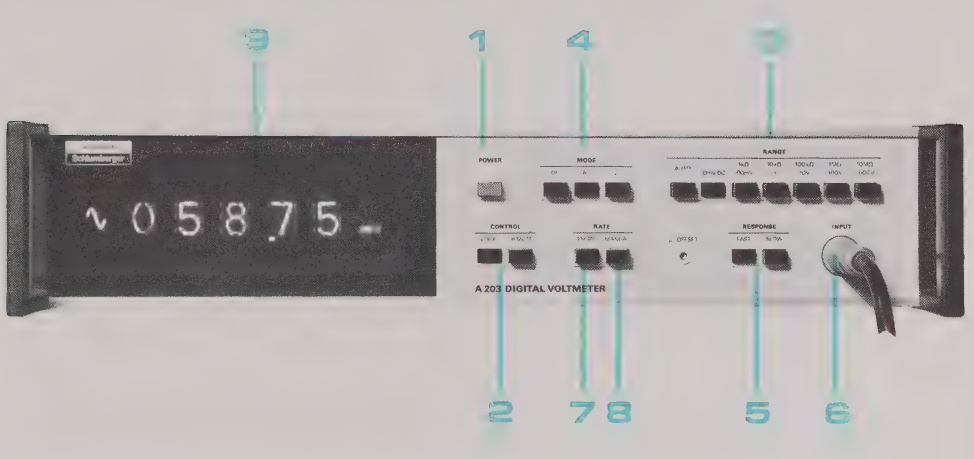
6. Press the 10/SEC push-button for repetitive measurement or, alternatively,

7. Press the MANUAL push-button for 'single shot' measurement.

8. Select SLOW or FAST RESPONSE for filtered or unfiltered measurement. If in doubt about the necessity to use the filter, press the SLOW button and if no change in the reading occurs then the filter is unnecessary. If there is a difference between the results of the filtered and unfiltered measurement, then the result with the filter is correct.

9. Read the voltage from the display and, if necessary, downrange to obtain greater sensitivity. The indicated polarity is that of the red lead with respect to the black.

AC VOLTAGE MEASUREMENT



Although the maximum ac voltages which may safely be applied to the instrument are:-

i) 1200V peak (846V rms) on the 100V and 10V ranges
ii) 300V peak on the 1V and 100mV ranges

} (or less than 6 x 10^6VHz on A205 and A225).

the 1V and 100mV ranges will withstand 1200V peak for up to 2 seconds. Thus, for AUTO range purposes the range of input voltage can be 0 to 1200V peak.

1. Switch POWER on.

2. Select LOCAL or REMOTE. If a fan out unit is fitted and REMOTE is selected, see the section of this manual which covers remote operation for a list and description of the remote control facilities. If LOCAL is selected read on from step 3.

3. Choose an appropriate range or AUTO range.

4. Press the AC MODE push-button.

5. Select SLOW or FAST RESPONSE depending on the low frequency limit required: SLOW for frequencies down to 20Hz or FAST for frequencies down to 100Hz. SLOW is not available in conjunction with AUTO. As soon as the voltmeter detects that SLOW and AUTO range have been selected it automatically goes to the FAST RESPONSE mode.

6. Connect the input lead to the unknown voltage source, red to signal high and black to signal low.

7. Press the 10/SEC push-button for repetitive measurement or, alternatively.

8. Press the MANUAL push-button for 'single shot' measurement.

   Note: If 10/SEC is selected the instrument displays the result of measurement ten times a second and it will be necessary to wait 1 second (FAST) or 5 seconds (SLOW), after connecting the signal to the input, for an accurate result.

   If MANUAL is selected the display is updated 1 second after pressing the button. During this time WAIT is displayed. For an accurate result if SLOW is selected, the input signal must be connected for 4 seconds before the button is pressed.

9. Read the voltage from the display and, if necessary, downrange to obtain greater sensitivity. The displayed reading is rms voltage assuming a sine wave input, using an A203 or A223. The A205 or A225 will read rms regardless of waveshape (within the limits of the specification).

RESISTANCE MEASUREMENT

1. Switch POWER on.

2. Select LOCAL or REMOTE. If a fan out unit is fitted and REMOTE is selected see the section of this manual which covers remote operation, for a list and description of the remote control facilities. If LOCAL is selected read on from step 3.

3. Choose an appropriate range or AUTO range.

4. Press the Ω MODE button.

5. Connect the input lead to the unknown resistance.

6. Press the FAST RESPONSE button. Although SLOW RESPONSE can be used in the Ω mode, if resistances above 50kΩ are being measured the time constant of the filter is increased with a corresponding increase in the time taken for measurement.

7. Press the 10/SEC push-button for repetitive measurement, or alternatively,

8. Press the MANUAL button for 'single shot' measurement.

9. Read the resistance from the display, changing range if necessary.

CURRENT MEASUREMENT

Although current measurement is not a facility provided by this voltmeter, it is easily effected by measuring the potential difference developed across a known precision resistance. The type of resistor used is important: for dc use either a precision wire wound component or, if available, a standard resistor; for ac use a metal film precision resistor.

Alternatively, the Solartron Current Adaptor EX3180, converts any of the voltmeters in this range to an AC/DC digital ammeter capable of measuring currents in the range 1nA to 2A. Full connecting details and operating instructions are given in the manual of the EX3180.

SECTION 4 Measurement Techniques

The user who is only slightly familiar with the practice of precision measurement will find the *MASTER SERIES* of voltmeters very easy to use. The layout and logical operation of the controls, the information presented by the display and the connection of the unknown signal incorporate several new features that have not been provided in other digital voltmeters. This results in an instrument which is so simple that the totally inexperienced can take measurements confident that the control settings and the readings are correct.

The following notes are written for those who wish to know more about the techniques of precision measurement. They also provide a guide as to the best way of employing the voltmeter in more unusual measurement situations.

INPUT RESISTANCE

In making a measurement of voltage virtually all instruments take a current from the source whose voltage is being assessed. The one exception is the true potentiometer in which, at balance, no current is taken from the source. The current taken by the measuring device gives a voltage drop across the internal resistance of the source so that the measured voltage is less than the true emf of the source (Fig. 4.1).

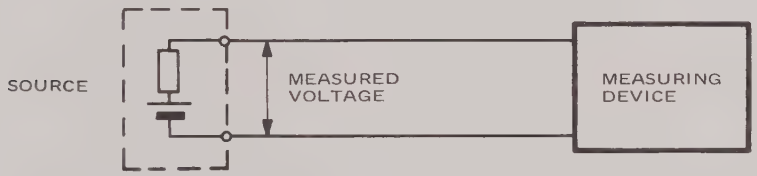


Fig. 4.1 *Current taken by a measuring instrument can cause a voltage drop across source resistance.*

A good moving coil meter will take a current of 10μA (100kΩ/V) so that if the source resistance were 1kΩ the voltage drop would be 10mV. This would be pretty hopeless for 'precision' work since a voltmeter with such a low input resistance would read 1.4900V instead of 1.5000V.

Fortunately electronic feedback techniques can give a digital voltmeter such a high input resistance that in most practical work the effect can be ignored. Thus the A200 series, when measuring dc on the more sensitive ranges, has an input resistance in excess of 10GΩ (1GΩ on 10mV range). This means that the source resistance will have to exceed 1MΩ before an error of 1 digit is obtained. (See also effect of input current discussed later). This may sound a little vague; it is not possible to define the input resistance more closely because a group of voltmeters will have differing gains in their input amplifiers; although this has no effect whatever on the accuracy, the input resistance may be 20GΩ or 53GΩ but will never be as small as 10GΩ.

On the 100V and 1000V dc ranges it is not possible to apply the unknown input directly to the input amplifier; it must be first attenuated. The attenuator must be very accurate and stable and must withstand high input voltages, so wirewound resistors are employed. It is difficult and expensive to make the attenuator of very high value resistors, so a 10MΩ network is used. Hence, on the 100V and 1000V ranges the voltmeter input resistance is 10MΩ ±0.1%, and errors arising from source resistance can be calculated with reasonable accuracy. For example, on the two highest voltage ranges, a source resistance of 1kΩ will cause the result to be 0.01% low, i.e. by 1 digit in 10 000.

INPUT CURRENT

All solid state devices are current operated hence the amplifiers of these voltmeters have a current flowing at the input terminals even when the input signal is zero. By careful design this current can be made almost insignificant and in fact is less than 100pA (10^{-10}A). During warm-up (for about 30 minutes after switch-on) the current will vary, since it has a temperature coefficient of approximately 2pA/°C, and will then stabilise. Taking the input Hi terminal as a reference the current may flow into or out of this terminal and must therefore be regarded as lying between the values of +100 and -100pA.

It should be realised that the effects of input current are additional to the effects of input resistance. Thus, to take a ridiculous example, if on the 10mV range (A200, A203) a 10mV source is measured with a source resistance of 1MΩ the input resistance alone (1GΩ) would give a reading that is up to 10μV low. But an input current of 100pA will introduce an additional error of 100μV which can add to, or subtract from, the error due to input resistance. Thus, in this extreme example, there is uncertainty (rather than a defined error) which may lie anywhere from 110μV low to 90μV high (Fig. 4.2).

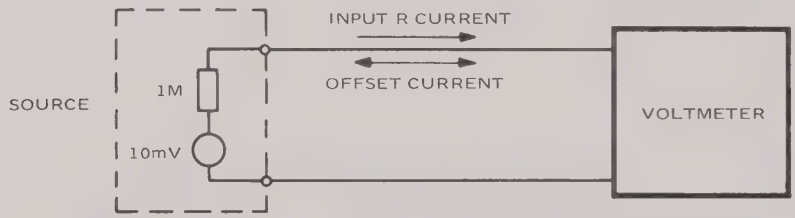


Fig. 4.2 *Current taken by input resistance flows into the Voltmeter; offset current may flow either way. Both effects are present together.*

The conditions given in the above example will probably never be met by the average user because low level signals nearly always have a source resistance of less than 10kΩ, in which case the errors are insignificant. If in a rare situation a low level measurement must be made on a high source resistance the offset current can be monitored and reduced to a very low value in the following way (Fig. 4.3).

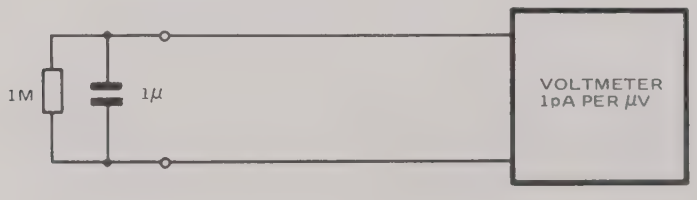
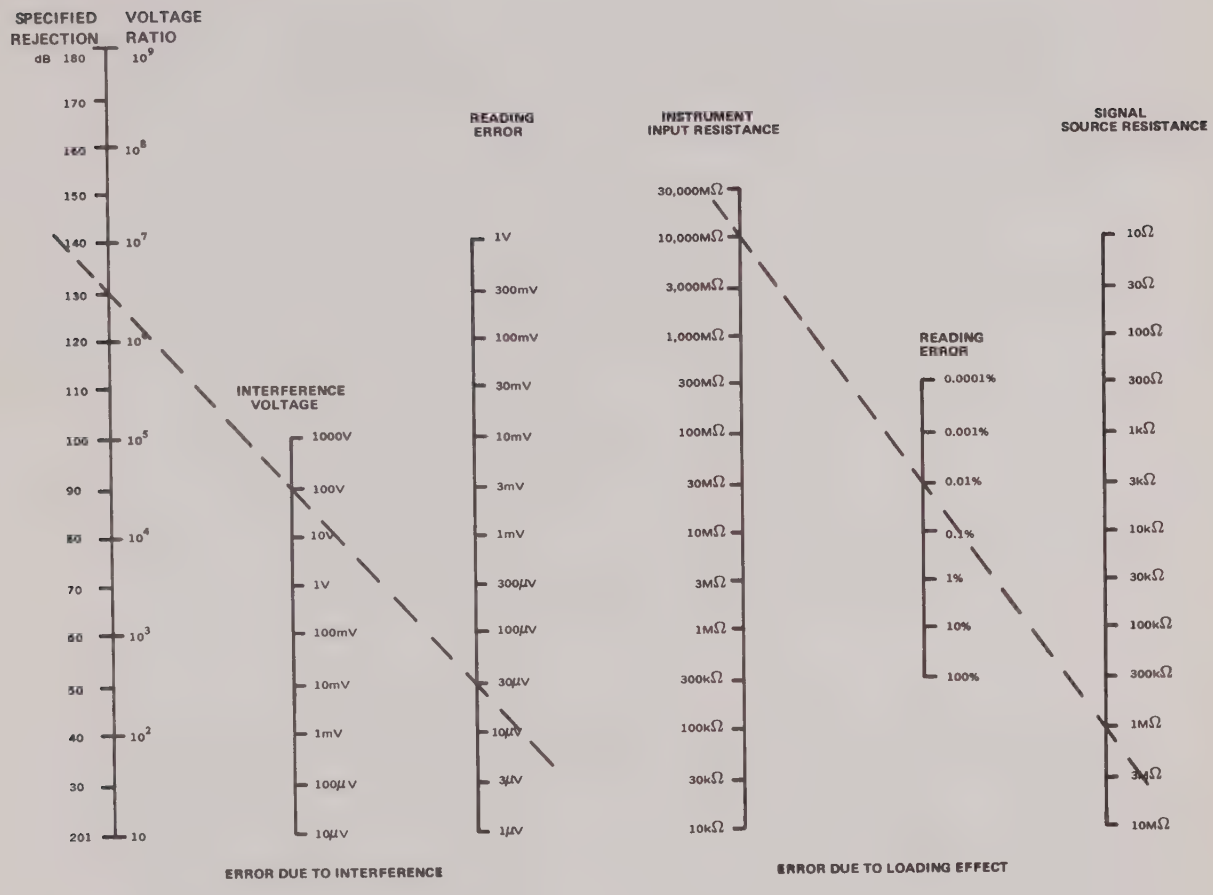


Fig. 4.3 *Using a known resistor the voltmeter can measure its own offset current.*



Remove the top outer cover plate, switch on and allow the instrument to warm-up for 30 minutes. Connect across the input cable a 1M resistor in parallel with a low voltage 1μF capacitor – keep the connections short to minimise 50Hz pick-up. Allow a minute or two for thermal effects to disappear, with a short across the capacitor to dissipate any small dielectric storage; then remove the short circuit.

With the voltmeter on the 10mV range dc (A200, A203) the display represents 1pA per digit, while on the 100mV range (A220, A223) it is 10pA per digit. Through the top of the screened compartment on the right is a pre-set control called INPUT CURRENT which may be adjusted to bring the reading to almost zero. It probably will not stay at zero because very small drifts of a few pA are inevitable, but it will enable a measurement to be made on a high source resistance with less uncertainty in the short term. Over periods greater than a few hours, and with changes in ambient temperature, the current will drift by tens of pA. Hence the formal instrument specification only claims $\pm$100pA for long term use.

ASSESSING INPUT RESISTANCE

From the foregoing it will be realised that it is not possible to check the extremely high input resistance by using instruments as though it were a physical resistor. Furthermore the measurement is complicated by the presence of the offset current.

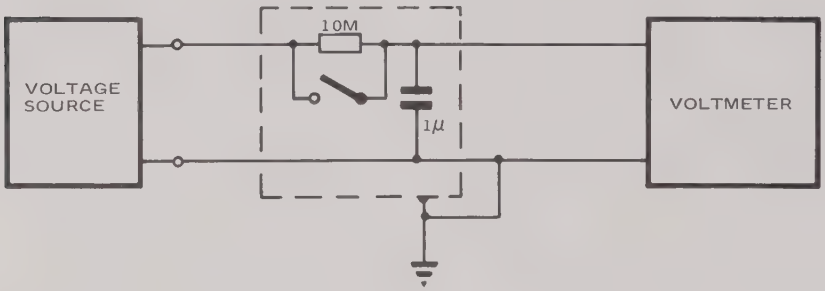


Fig. 4.4 *An assessment of input resistance will include an effect due to offset current.*

With the arrangement shown in Fig. 4.4 the components are mounted in a screening box which is bonded to earth in order to minimise 50Hz pick-up. The voltmeter is set to the 10V dc range and the voltage source to approximately 10V. The switch is first closed and the reading noted, (say 10.057). Upon opening the switch the reading will fall over a short period of time to, say 10.052. Ignoring the offset current this is a fall of 5mV in 10V, which is a factor of 2×10^3. So the input resistance is $2 \times 10^3 \times 10M\Omega = 20G\Omega$.

A proportion of the change will be due to offset current and this will become a greater proportion on the lower voltage ranges. So if any reasonable assessment of input resistance is to be attempted, the current should be first reduced to a few pA as described earlier. As a check the measurement can be made using each polarity of input voltage in turn. A difference in the readings taken with the $10M\Omega$ in circuit will then give a measure of the offset current.

The difficulty of an accurate assessment of input resistance on more sensitive ranges is the only reason why $1G\Omega$ is specified for the 10mV range. The value is probably in excess of $10G\Omega$, but it is impossible to measure it with any reasonable degree of certainty.

SPURIOUS VOLTAGES

Although small emf's occur in the voltmeter input circuits they are compensated for during calibration. Thereafter, when the instrument has warmed-up for about 30 minutes, they are so stable as to be quite insignificant to the user. The drift in the input amplifier is equivalent to an input voltage change of approximately $1\mu V$ per week. The user therefore need not make any compensation or adjustment in order to achieve accurate results.

The voltmeter will faithfully measure any input that is applied to its terminals; it is the responsibility of the user to ensure that the input contains only the voltage that he wishes to measure. In low level work – with perhaps a few tens of microvolts – this may require some care and thought in the arrangement of the circuit.

As an example consider measuring the voltage produced by passing a very small current through a wirewound resistor. On the 10mV range the reading is recorded as $126\mu V$. But the resistor is placed – in the sun or near a power transistor – so that one end is a little warmer than the other.

Because of the dissimilar materials used in the wire of the resistor and in the copper connections a net thermal emf will exist of possibly 40μV/^{o}C. Thus a differential of 0.5^{o}C across the resistor could mean that the true result should be either 106μV or 146μV. The voltmeter cannot possibly distinguish between the wanted and unwanted parts of the signal that is applied to it. In this example, without altering the conditions of the resistor in any way, a measurement should be made with the small current flowing in each direction. In one case the thermal emf will add and in the other it will subtract. So the mean of the two results will eliminate the error.

Metal oxide resistors and reed relays are two other components in which thermal emf's can bring about similar errors. In the reed relay the heating of an operating coil may contribute to this and it may be desirable to employ two reed switches in the same coil so that, when connected in series, thermal emf's are self-cancelling. In the A200 range of voltmeters the reed assemblies, specially developed by Solartron, are used in circuits where these thermal effects are quite insignificant.

When the unwanted emf can be established and it is steady it can be backed off by using the μV ZERO control provided on the voltmeters. This has a range of $\pm$15μV.

In attempting precision measurement of low level signals effects other than thermal emf's can also cause problems. Leakage across an insulating material when degraded by high humidity or an industrial atmosphere may produce an unsuspected voltage across a source resistance. Coaxial cables when flexing under vibration can generate quite high transient voltages due to the screen scrubbing the polythene insulant; use low noise cables.

SERIES MODE INTERFERENCE

The examples of thermal emf's given above can be regarded as forms of interference because they interfere with the accurate assessment of the unknown signal. They are in series with the signal and voltmeter input and represent a special case of series mode interference because there is nothing that the voltmeter can do towards rejecting dc interference while measuring a dc signal.

Series mode ac interference is a different matter. Because of their basic design principle these voltmeters will ignore all the usual forms of ac and noise that may be intermingled with the dc signal. Hence in all normal measurement work the user will be unaware of ac interference and it will not cause errors. Nevertheless it would be possible to introduce such a degree of interference that the voltmeter would be unable to cope, so the keen user may be interested in the mechanism that brings about rejection.

The most common form of ac interference is simple 'hum' – i.e. 50Hz superimposed on the dc signal. This can be visualised either as pick-up on the connecting leads, as shown in Fig. 4.5 (a), or as a generator that is a part of the source, as in Fig. 4.5 (b). In both the result is the same and is shown graphically in Fig. 4.6.

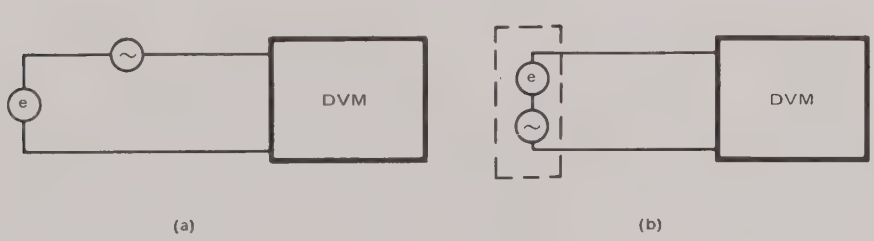


Fig. 4.5 *Interference at 50Hz can arise from pick-up on the leads (a), or may be inherent in the source (b).*

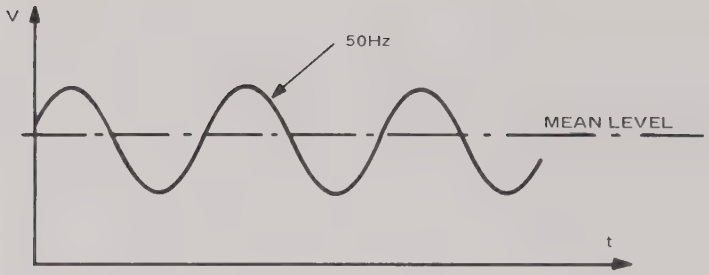


Fig. 4.6 *50Hz superimposed on the dc level that the voltmeter is trying to measure.*

Users of oscilloscopes will be familiar with this sort of picture and will know that the ac component is typically a few millivolts peak-to-peak. This may be superimposed on a wanted dc signal of a mere 100μV.

These voltmeters employ the dual-ramp technique which is described in the Principles of Operation.

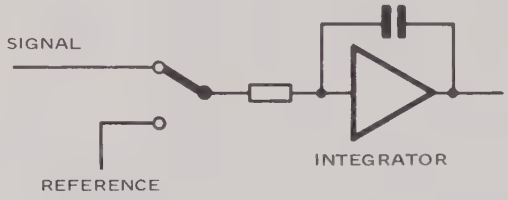


Fig. 4.7 *In the dual-ramp system the integrator is switched first to the signal (ramp-up) and then to the reference (ramp down).*

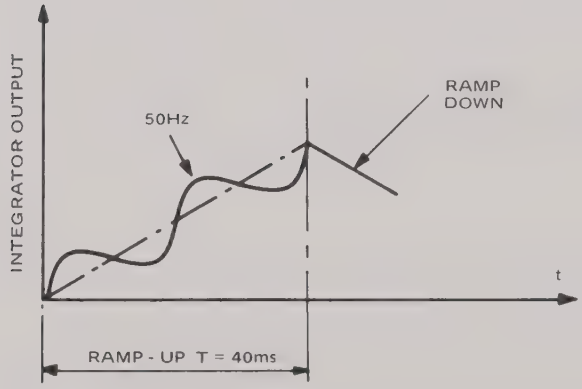


Fig. 4.8 *At the end of ramp-up the integral of any 50Hz component is zero.*

The integrator is connected to the input signal (actually to the output of the input amplifier) to start the initial phase of the measurement. This phase is called 'ramp-up' and lasts for a time that is defined by the frequency of the clock and the capacity of the counter. During ramp-up the output of the integrator is proportional to the integral of its input. If ramp-up lasts for T seconds then it is the integral of the input over T seconds that finally remains on the integrator

capacitor when the switch opens. It is this voltage that is assessed during ramp-down. When T is made equal to the period of the ac interference (or to any whole number of periods) the integral of the ac at the end of ramp-up will be zero. Thus ramp-down starts from a voltage that is proportional only to the dc component (actually to the mean level) of the input. Fig. 4.8 illustrates the situation for a particular case of 50Hz interference.

In this series of voltmeters the ramp-up time (T) is 40ms so that they inherently have rejection of 25Hz, 50Hz, 75Hz, 100Hz..... etc. This is shown by the curves of Fig. 4.9, where rejection notches occur every 25Hz, in which the rejection ratio is given in dB.

To digress for one moment – the decibel (dB) may be unfamiliar to some. It is used here to specify a voltage ratio. The relationship is:

Number of decibels = $20 \log_{10}$ (voltage ratio)

Example: Voltage Ratio = 1000

Number of dB = 20 x 3 = 60dB

dB	Ratio	dB	Ratio
1	1.1	9	2.8
2	1.3	10	3.2
3	1.4	20	10
4	1.6	40	10^2
5	1.8	60	10^3
6	2.0	80	10^4
7	2.2	100	10^5
8	2.5	120	10^6

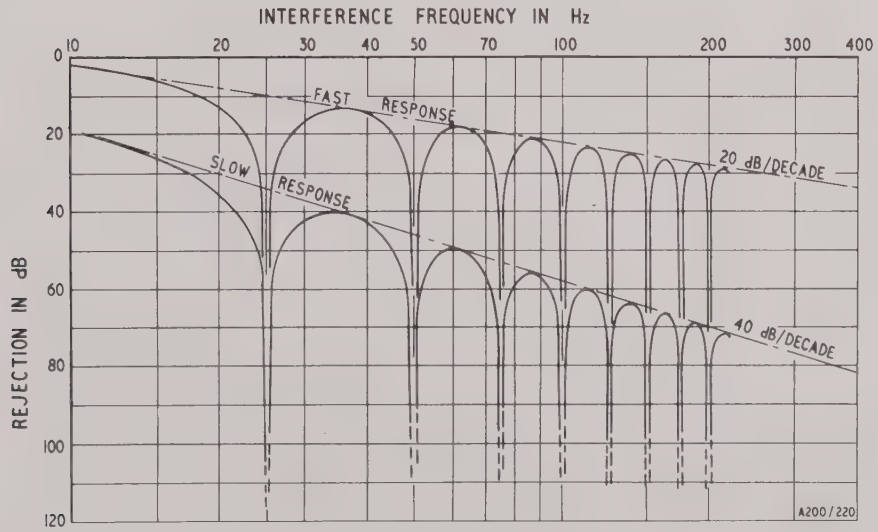


Fig. 4.9 *SERIES MODE REJECTION*

These curves show the rejection that is attained by A220 and A223 for interference with dc measurement at the frequencies given.

A200 and A203 have ramp-up time locked to the mains period so that the curves shift along the frequency axis in step with changes of mains supply frequency.

Decibels add; but ratios must be multiplied. Thus:

$$36dB = 20 + 10 + 6dB$$

$$= 10 \times 3.2 \times 2 = 64 \text{ ratio}$$

If the ramp-up time were precisely 40ms there would be virtually infinite rejection of frequencies at multiples of 25Hz. But the clock frequency cannot be absolutely constant, and although this has no effect on measurement accuracy, the specified rejection must be less than infinite. Hence with A220 and A223 the rejection at 50Hz is better than 60dB; this means that any error will be, at worst, one thousand times smaller than the interference. Usually 50Hz interference arises from the supply mains and occasionally, when the national supply is heavily loaded, this will fall below 50Hz and the integration will be less than perfect. To allow for this as well as for small variations of clock frequency the A220 and A223 specify 36dB for 50Hz $\pm$1%.

Since the precise clock frequency has no effect on the accuracy of the result this frequency may be varied so that ramp-up time is always equal to two mains supply periods. A200 and A203 have a digital servo built in to do this and, as a result, the series mode rejection to mains interference is in excess of 70dB even though the supply frequency may vary by $\pm$2%.

COMMON MODE INTERFERENCE

Interference can also arise from unwanted voltages which are common to both voltmeter leads. Consider Fig. 4.10 – here the signal source is earthed locally and the voltmeter input has also been earthed.

Fig. 4.10 *An 'earth' at both source and voltmeter input may introduce common mode interference. For this reason the voltmeter input is fully isolated.*

There is a distinct possibility that the two 'earths' are not at a common 'zero' potential; in extensive industrial plants widely separated 'earths' can have as much as 10V between them. This situation is equivalent to that of Fig. 4.11 where the source is known to be at a finite potential with respect to earth.

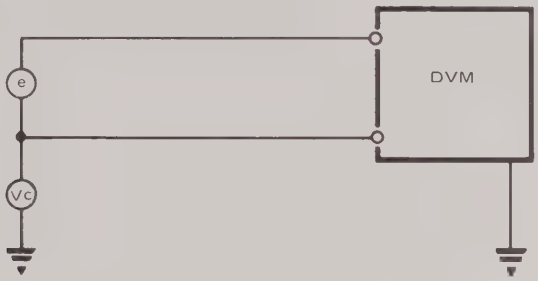


Fig. 4.11 *The source can be at a high potential above earth without causing errors.*

For example, a thermocouple used to measure the temperature of a furnace element might be generating 1mV of dc signal while kept at 240V ac to earth. Obviously it would be ludicrous to earth the voltmeter input, although the chassis and most of the circuits are earthed via the mains supply lead.

All the voltmeters in this series have been engineered so that the input circuits are extremely well isolated from the chassis which is connected to mains earth. In all normal measurement work the small current which is driven down the leads to earth by a large common mode voltage will not cause any error. This voltage should be restricted to 500V purely to ensure safety for equipment and personnel.

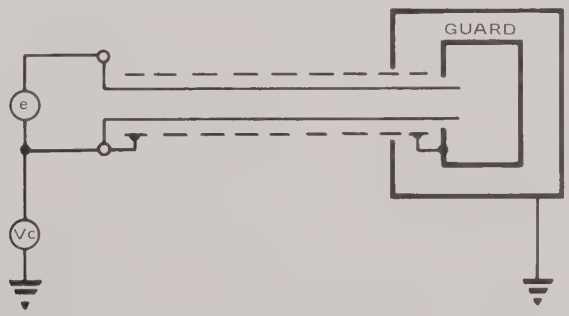


Fig. 4.12 *In the lead provided with the voltmeter Guard is strapped to Lo (BLACK) within the free end of the cable.*

The lead supplied with each voltmeter is shown in Fig. 4.12. Within the instrument the cable screen is wired to the guard box and at the free end the screen is strapped to the black wire. Hence the guard is effectively preserved right up to the signal source and common mode current flowing in the screen and via leakage to earth cannot affect the measurement in any way.

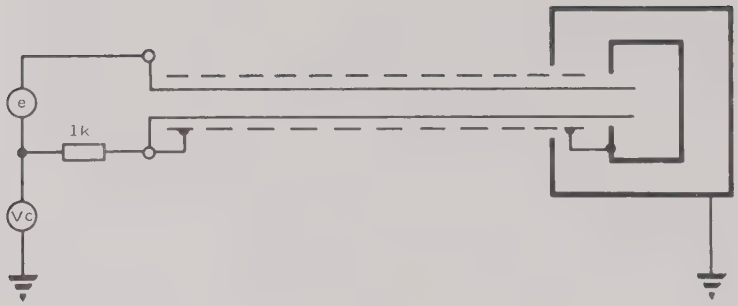


Fig. 4.13 *A rare, but more difficult, situation is where common mode current flows through lead resistance. This is entirely overcome by the arrangement of Fig. 4.14.*

In some measurement situations a common mode voltage can have an affect on the reading. Most users will never meet the problem, but those who do can still eliminate error by using the voltmeter correctly. When there is resistance associated with the source – perhaps inherent in the source, or in connecting leads – the common mode current can flow through this resistance. Examples are: the resistance of strain guages; long compensating leads from a thermocouple. This is illustrated by Fig. 4.13 where it will be seen that current flowing from Vc to earth down the screen must pass through the resistance. If the guard-earth leakage is assumed to be the specified minimum of $10^{10}\Omega$ and Vc is 100V dc the common mode current will be 10^{-8} A. Taking a lead resistance of 1kΩ, 10^{-8} A will give a voltage drop of 10μV. Since the voltmeter cannot reject dc interference the worst error will be 10μV.

If the source of common mode is ac the stray capacitance from guard to earth is more important. The figure specified is 500pF, which is about 6MΩ at 50Hz. With Vc now 100V rms the drop across 1kΩ is approximately 17mV rms or 24mV peak. This appears at the input terminals and the inherent rejection of series mode will be effective in reducing reading error to much less than 24mV. With A200 or A203 the final reading error at worst will not exceed 8μV.

In these examples a 1kΩ resistance has been assumed in one lead. Obviously the magnitude of the error is proportional to this resistance and it is accepted practice to specify common mode rejection with 1kΩ unbalance in the leads using the configuration of Fig. 4.13. Even in these exceptionally adverse circumstances the errors can be overcome by using a different input arrangement as in Fig. 4.14.

This is provided by using a special lead EX3183 from which the 4 cores and the screen are brought out as separate terminations.

Fig. 4.14 shows the EX3183 adapted for three terminal measurements. Alternatively, the EX3193 (three terminals - signal high, signal low and guard) is available.

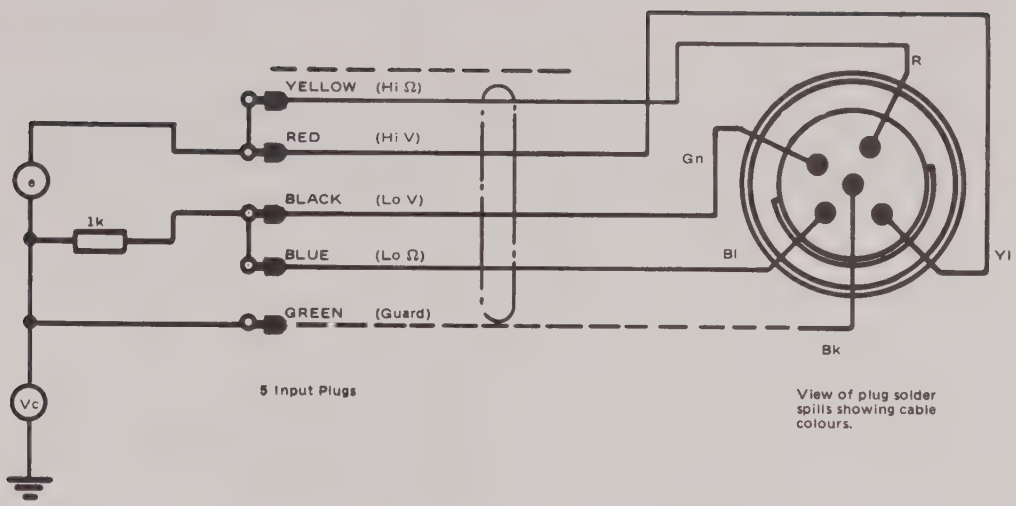


Fig. 4.14 *A special lead (EX 3183) is obtainable from Solartron which enables the Guard to be driven directly by the common mode voltage.*

The 4 cores are required for 4 terminal resistance measurement as described later. For fully guarded voltage measurement only 3 terminals are necessary – signal high, signal low and guard (screen). When on voltage ranges the YELLOW and BLUE cores are connected within the voltmeter to RED and BLACK. To prevent these plugs accidentally making contact with earth, or with other circuits and perhaps causing damage, the YELLOW should be plugged into RED, and the BLUE should be plugged into BLACK. GREEN is connected directly to the source of interference thus driving the guard at the common mode voltage and preventing common mode current flowing through the lead resistance. Using this arrangement, even though the interference were the maximum permitted (500V peak 50Hz), it is most unlikely that there would be any error discernable – even on the most sensitive range.

For a more complete treatment of interference in digital voltmeter measurements the reader is referred to:

1. 'Digital Voltmeters and Interference'
2. 'Principles of Interference Rejection'

both of which are available free on request to Solartron.

NOISE

The foregoing explanation of interference rejection has dealt specifically with 50Hz because by far the most common source of interference is the mains supply, or fields radiated from mains wiring and mains energised equipment. The curves of Fig. 4.9 show that at higher harmonics of 25Hz rejection is improved so that 100Hz ripple from power supplies or 400Hz aircraft and ship supplies are unlikely to introduce difficulty. When considering general 'noise' of no specific frequency the integration process inherent in the dual-ramp technique still applies. The resultant noise component over 40ms integration will tend to zero.

FILTERS

For all normal dc measurement the use of the filter which is built into the voltmeter (SLOW) is unnecessary. Although the increase in response time would be of no consequence during laboratory work, the delay may be of significance in data logging or in automatic test systems. In

these cases the use of FAST will give adequate interference rejection. In rare situations the interference may be so excessive that SLOW produces some benefit on dc measurement. This can be established by changing from FAST to SLOW and observing if there is a difference in reading. If there is a difference SLOW gives the correct answer.

AC VOLTAGE

The unadorned digital voltmeter is able to measure dc voltage only. It can be adapted to measure ac by including an ac-dc converter ahead of the dc input circuits. This has been done in the *MASTER SERIES.*

A203 and A223 include a converter which may be regarded as a sophisticated full-wave rectifier. By including semi-conductor rectifiers in an operational amplifier loop non-linearities in the transmission characteristics of the rectifiers are eliminated. The smoothed output of such a rectifier system is a dc level which is proportional to the *mean* value of the ac; it is this which is passed to the dc voltmeter for measurement. Fig. 4.15 shows this action.

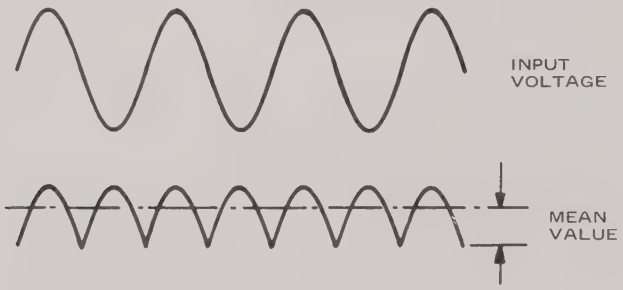


Fig. 4.15 *An ac input voltage is rectified in the ac-dc converter and the smoothed mean value is passed to the dc circuits for measurement. Although the mean value is sensed the rms value is indicated.*

There are three ways of specifying the amplitude of an ac voltage: the mean; the peak; the root-mean-square (rms). For any periodic function there is a precise relationship between these which can be calculated. In the case of a sine wave:

$$\text{Mean} = \frac{2}{\pi} \text{ peak}$$

$$\text{rms} = \frac{1}{\sqrt{2}} \text{ peak}$$

When speaking of ac voltages (e.g. 240V) it is an accepted convention that the rms value is understood unless mean value or peak value is stated. The rms is also used in most calculations. It has therefore become accepted that a measuring instrument will read rms, although the vast majority actually measure the mean. For these reasons A203 and A223 are scaled to give a reading of the rms of the input on the assumption that the input is a perfect sine wave.

Distortion is a factor which can occasionally introduce errors as a result of this assumption. The reader will be familiar with the analysis of a complex waveform which breaks down a periodic function into a fundamental sine wave plus a series of harmonics. It is the harmonics which represent the distortion content, the degree of distortion being dependent upon the order,

the amplitude and the phase of the harmonics. It will be extremely rare that the detailed harmonic content is known, but what may be known is the Total Distortion which is, in effect, the sum of the total harmonic content. Measurement errors would be greatest for a mean sensing rms indicating instrument is the total distortion was all third harmonic. Hence this assumption would enable an estimate to be made of the worst possible errors. In this case:

$$\text{Max percentage error} = \frac{1}{3} \text{ total percentage distortion.}$$

Thus a total distortion of 0.3%, if all third harmonic, could give a worst error of 0.1%.

The voltmeter input impedance on ac is either 1MΩ or 10MΩ (depending on range) in parallel with a capacitance. At frequencies above a few tens of Hz the capacitive term will be dominant. The values are given in the formal specification and may be used to calculate the voltage drop across a source impedance at a particular frequency.

Consideration of Fig. 4.15 will show that the lower the signal frequency the more smoothing is necessary before the mean level can be passed into the dc measuring circuits. Therefore below about 100Hz a longer time constant filter (SLOW) is required in order to preserve measurement accuracy. AC measurement with a digital voltmeter gives easily the best compromise between speed and accuracy over all other forms of ac measurement. But with low frequencies, using any measurement technique, the reading must have time to settle.

It has been pointed out that when measuring dc voltages the voltmeter cannot reject thermal or other dc interference. In exactly the same way there cannot possibly be rejection of series mode ac interference when measuring ac voltages. Common mode rejection is, however, still preserved, and the input circuits on ac are still fully isolated from chassis and from earth. For those who are interested in pursuing the subject in greater depth a paper on AC Voltage Measurement, with particular reference to waveform errors, is available free on request to Solartron.

RESISTANCE

Voltmeters A203 and A223 measure the value of a resistor by passing a defined current through the resistor and determining the potential difference that results. The current is small (600μA on 1kΩ range) so that power dissipated in the resistor is minimised. In measuring low values of resistance the voltage dropped along the current carrying leads can sometimes introduce errors. In these instruments, when using the lead provided, the effect is entirely eliminated by operational amplifier techniques within the voltmeter.

The most sensitive resistance range of 1kΩ with its 100mΩ sensitivity is satisfactory for most low value measurements. Should there be a requirement for increased sensitivity on low values the voltmeter can be used on a dc voltage range to measure the potential difference across the resistor with a current provided from an external source (Fig. 4.16).

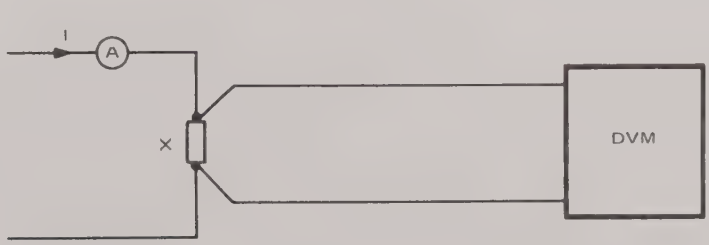


Fig. 4.16 *A very low value resistance may be measured by measuring the voltage devloped across it. The voltage leads should be connected close to the ends of the resistor.*

If I is 1mA and the voltmeter is on the 10mV dc range a reading of 12.631mV means that x is 12.631Ω. Obviously other appropriate currents and voltage ranges could be used. The first point to observe is that, in this example, the sensitivity is 1mΩ per digit. Hence the voltmeter connections must be made right at the ends of the resistor and must not embrace any significant length of the current carrying leads (10cm of 22SWG copper wire is approximately 4mΩ).

A second point is that the accuracy is affected directly by the precision of the current setting. There would be little point in using a moving coil multimeter to set current and then record a reading of 12.631Ω.

An improved technique is shown in Fig. 4.17.

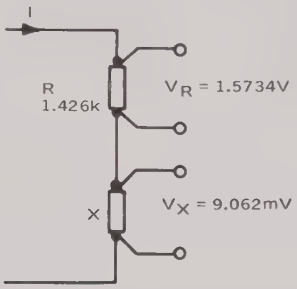


Fig. 4.17 *A ratio measurement avoids having to set a precise value of current.*

Here a resistor R, whose value is known, is connected in series with the low value unknown x. R can be a much higher value than x. If R is not already known it can be measured on one of the ohms ranges. The voltmeter, on dc auto-range, is connected across R and the current supply is adjusted to give a reading greater than half full-scale. The precise value of V_R is not important; neither is the value of the current I. In this example I could be simply provided by a 1.5V dry cell. The reading V_R is recorded. The voltmeter is transferred to x and the reading V_x is noted. The value of x is then given by:

$$x = R \frac{V_x}{V_R} \text{ ohms}$$

Using the values shown in Fig. 4.17:

$$x = \frac{1.426 \times 10^3 \times 9.062 \times 10^{-3}}{1.5734} = 8.213\Omega$$

If x is being set to different values it may be necessary to measure V_R each time because, unless I comes from a constant current supply, changes of x may significantly alter I.

Should it be necessary to measure resistance at a distance from the voltmeter which is beyond the reach of the standard input lead, a special lead EX 3183 may be obtained from Solartron. In this the four cores and screen are terminated separately, as shown in Fig. 4.18. This cable should be extended to reach the point of measurement by means of a similar 4 core screened cable, and connected to the remote resistor as shown.

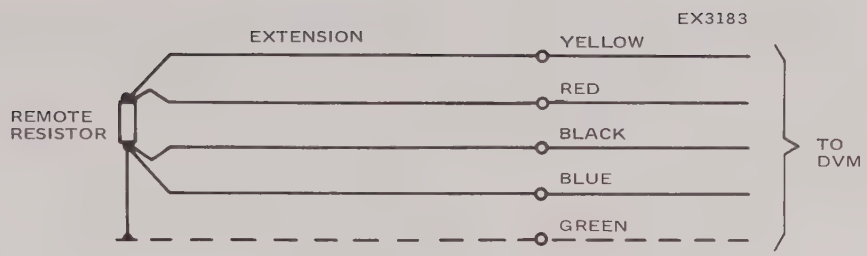


Fig. 4.18 *In measuring a remote resistor, lead compensation can be preserved by using the special input cable (EX 3183, obtainable from Solartron) and extending it by a 4 core screened cable.*

This arrangement will preserve the compensation for lead resistance on any ohms range up to a maximum of 1Ω per wire. Using an extension of 7/.0076 wires a length of 100m can be safely used.

CURRENT

For determining current (dc or ac) the voltmeter can be used to measure the voltage drop when the current is passed through a known resistor and the value of the current thereby calculated.

If currents of the same order are to be measured frequently, the provision of a resistor of suitable value can save the chore of calculation. For example with a 1Ω resistor and the voltmeter on the 1V range currents up to 1.9999A can be determined by direct reading amps instead of volts. If the results are to be consistent with the accuracy of which the voltmeter is capable the resistor must be known precisely. This can be achieved by taking a value that is slightly high and wiring others in parallel while measuring the total value as described earlier. The main resistor should be a precision type capable of good stability; wirewound is suggested for dc work, but for ac measurement metal film resistors should be used to avoid inductance effects.

In applications where a wide range of currents are to be measured the Current Adaptor EX 3180 should be considered. This has precision resistors built-in. When used with a Voltmeter in the *MASTER SERIES* current ranges of 1A down to 10μA can be selected by push buttons giving a maximum sensitivity of 100pA.

LONG TERM INTEGRATION

In measuring a steady dc input the number of pulses gated to the counter during ramp down is the measure of the input voltage. If this number of pulses is p:

$$p \propto \text{input voltage}$$

actually $$p \propto \frac{1}{T}\int_0^T v(t)dt$$ where $v(t)$ is a varying input

T is ramp-up time

or $$p \propto V \text{ where } V = \frac{1}{T}\int_0^T v(t)dt$$

On a given range each single pulse results in 1 digit in the display, and the value of 1 digit depends upon the range. Thus if 1 digit represents S volts (Sensitivity), p digits (i.e. p pulses) represents pS volts.

But on A200 and A220 display at nominal range is 10 000.

Thus $S = R \times 10^{-4}$ where R is nominal range value in volts.

(e.g. on 100mV range, $S = 100 \times 10^{-3} \times 10^{-4} = 10\mu V$).

Then $V = pR \times 10^{-4}$ for each individual reading.

If N readings are taken: $V = \frac{Np}{N} R \times 10^{-4}$

But Np is the total pulses accumulated during N measurements.

Put $Np = P$

Then $V = \frac{P}{N} R \times 10^{-4}$

In a time t secs there are $10t$ readings, so $N = 10t$:

$$V = \frac{P}{10t} R \times 10^{-4}$$

$$V = P \frac{R \times 10^{-5}}{t} \text{ volts}$$

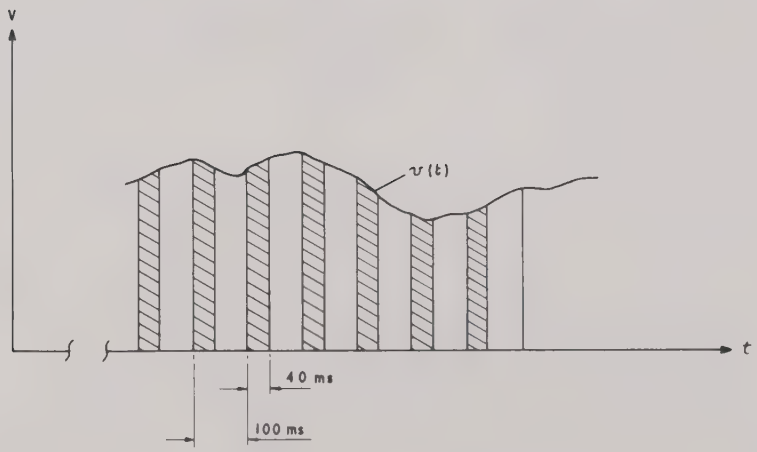


Fig. 4.19 *Long term averaging process*

As ramp-up lasts for 40ms a long term measurement is the result of repeatedly taking the average value over 40ms in each 100ms (Fig. 4.19). Thus the final average value will be correct only when the variations in the input are slow relative to 100ms. This is exactly the situation in which long term averaging is required – for example, gradual variations in a chemical plant. Obviously it is valid only when the input is continuously of one polarity, since the gated pulses do not contain polarity information.

Thus a long term average of a slowly changing input may be obtained by taking the output from pin k on the fan-out unit to an external counter.

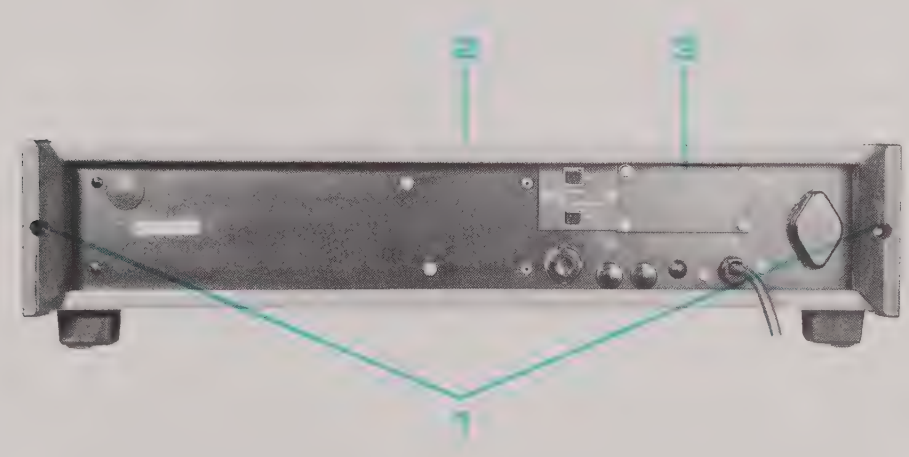
$$\text{Average} = \frac{\text{total count x nom. range in volts}}{\text{count time in seconds}} \times 10^{-5} \text{ volts.}$$

SECTION 5 Data Systems Use

SYSTEMS USE

The addition of a fan-out unit makes this voltmeter eminently suitable for use in a data logging or automatic test system. It enables full remote control of all the front panel functions (except power) and provides display information and the various control signals necessary in such systems.

INSTALLATION OF FAN-OUT UNIT A204



1. Release the two side panel captive securing screws and withdraw the side panels.
2. Remove the top cover.
3. Remove the blanking plate.
4. Insert the fan-out unit into the connector provided and, using the blanking plate screws, secure the fan-out socket to the rear panel.
5. Replace the top and side covers and secure.

RACK MOUNTING

Included with the accessories is a pair of combination handles/rack mounting ears for substitution with the standard handles. This is effected by removing the four handle retaining screws and the handles, and replacing with the rack ear/handles using the same screws.

In addition, if space is required between instruments within the rack for rack runners, it is necessary to remove the lower side panel retaining strips and the bottom cover, as follows:-

1. Release the rear feet.

2. Slide out the side panels.

3. Remove the lower retaining strips.

4. Remove the bottom cover.

The side panels may be replaced.

FAN-OUT FACILITIES (at rear socket)

PIN	FUNCTION	PIN	FUNCTION
A	1×10^0 (Staticised Display Information BCD)	d	Polarity +
B	2×10^0	e	Polarity −
C	4×10^0	f	1 BCD
D	8×10^0	h	2 Range Information
E	1×10^1	j	4 (See Output Information)
F	2×10^1	k	Gated Clock
H	4×10^1	m	1 BCD
J	8×10^1	n	2 Range Command
K	1×10^2	p	4 (See Remote Command)
L	2×10^2	r	Command CONTROL (LOCAL/REMOTE)
M	4×10^2	s	Contact Sample
N	8×10^2	t	Pulse Sample
P	1×10^3	u	Print Command (Pulse)
R	2×10^3	v	Print Command (Level)
S	4×10^3	w	Data is Changed (See Remote Command)
T	8×10^3	x	Data can Change (See Output Information)
U	1×10^4	y	Command AUTO range
V		z	Command RESPONSE (FAST/SLOW)
W		AA	Command MODE (DC, AC or Ω)
X		BB	(A203 and A223 only)
Y		CC	MODE Identification
Z		DD	(A203 and A223 only)
a		EE	
b		FF	
c		HH	0V

REMOTE COMMANDS

Remote control of the instrument is possible only when Fan-Out Unit A204 is fitted. Before applying remote commands to the instrument, REMOTE must be selected either electrically (at pin r of A204) or by the front panel switch.

Input Levels

Level '1' is $+2.4V < \text{'1'} < +6V$ at $100\mu A$ or open circuit

Level '0' is $-0.5V < \text{'0'} < +0.5V$ at 5mA sink

CONTROL

CONTROL	Pin r
LOCAL	1
REMOTE	0

Note: If LOCAL is commanded whilst the REMOTE switch is in, then the only switches under LOCAL control are POWER and RATE.

RANGE

Ranges are selected by addressing pins m, n and p with 1, 2, 4 B.C.D. If the decimal value of the range code is 'N' then the full scale (nominal) commanded is:

1×10^{-N} kV (A200, A203, A220, A223)

or $1 \times 10^{(1-N)}$ MΩ (A203, A223)

depending on the MODE selection.

Voltage Range	Range Code				Resistance Range
	p (4)	n (2)	m (1)	N	
1000V	0	0	0	0	10MΩ
100V	0	0	1	1	1MΩ
10V	0	1	0	2	100kΩ
1V	0	1	1	3	10kΩ
100mV	1	0	0	4	1kΩ
10mV (A200 A203 only)	1	0	1	5	—

Note: If 101 is applied when either AC or Ω is selected or for A220 and A223 the 100mV or 1kΩ range will be called.

If 110 or 111 is applied the 1000V or 10MΩ range will be called.

MODE

Available on A203 and A223 only.

MODE	Pin AA	Pin BB
DC	1	1
AC	0	1
Ω	1	0

AUTO RANGE

Auto range is selected by Level 0 at pin y.

RESPONSE

RESPONSE	Pin z
FAST	1
SLOW	0

RATE

Manual: If MANUAL has been selected by the front panel control, the instrument need not be in the REMOTE mode to be able to initiate measurements by pulse or contact sample.

If 10/SEC has been selected by the front panel control, either MANUAL must be selected or REMOTE control commanded by a 0 level at pin r of the rear socket before pulse or contact sample can be used to initiate a measurement.

If REMOTE has been selected by the front panel control, the MANUAL control must also be pressed once (to release 10/SEC button) before measurements can be initiated by pulse or contact sample.

Contact Sample: Contact closure between pins s and 0V (HH) with less than 2ms contact bounce.

Pulse Sample: Positive pulse at pin t of $>10\mu s$ duration and between +3V and +8V amplitude.

Pulse or Contact sample can be applied any time while Print Command Level is at '1' but preferably not earlier than 5ms after new range/mode/channel selection.

Repetitive: Press the REMOTE and 10/SEC push buttons but do *not* command REMOTE. Then the remote control of other functions is retained.

To change from continuous to pulse or contact sample, command REMOTE by 0 level at pin r.

DATA IS CHANGED

This input enables the user (system) to instruct the voltmeter that a settling time is required before the next measurement, because of a change of range and/or mode command data.

If command data is unchanged apply '0' at pin w

If command data is changed apply '1' at pin w

If the new command data is different, the '1' must be applied after DATA CAN CHANGE has gone to '0' and before SAMPLE (Pulse or Contact) command; this '1' must be maintained until DATA CAN CHANGE next goes to '0'. Thus, when the command data is different the internal digitise command will occur 10ms after SAMPLE command, whereas if it is unchanged the internal digitise command will occur 1ms after SAMPLE command.

OUTPUT INFORMATION

Output Levels: Level '1' is +2.4V $<$1 $<$+6V from 6kΩ source

Level '0' is -0.5V $<$0 $<$0.5V at 10mA sink

RANGE

There are two possible range output codes; Code 1 is identical to the range command code whilst Code 2 simplifies the interpretation of the output data, allowing the value to be read as; Reading (as an integer) x 10^{-N}V or kΩ. This effectively means that the range number, N, fixes the decimal point N places from the right of the measurement data and allows the value to be read in volts or kilohms.

The code is set by a single link on pcb No. 27 of the Fan-Out. Code 2 is normally connected before dispatch except when the dvm is supplied with a Compact - 33 Logger. To change to code 1 locate pins A, B and C at the bottom of pcb No. 27. If A and B are linked Code 2 is connected. The link should be moved to connect pins A and C for Code 1.

Code 1 (as Range Command)

Voltage Range	Range Output Code			N	Resistance Range
	j (4)	h (2)	f (1)		
1000V	0	0	0	0	10MΩ
100V	0	0	1	1	1MΩ
10V	0	1	0	2	100kΩ
1V	0	1	1	3	10kΩ
100mV	1	0	0	4	1kΩ
10mV	1	0	1	5	–

Value = Reading (as an integer) x $10^{-(N+1)}$V or x 10^{-N} kΩ

Code 2 Voltage Range Output:

Voltage Range	Output Code			N
	j (4)	h (2)	f (1)	
1000V	0	0	1	1
100V	0	1	0	2
10V	0	1	1	3
1V	1	0	0	4
100mV	1	0	1	5
10mV	1	1	0	6

Formula = Reading (as an integer) x 10^{-N} Volts

Code 2 Ohms Range Output:

Ohms Range	Output Code			N
	j (4)	h (2)	f (1)	
10MΩ	0	0	0	0
1MΩ	0	0	1	1
100kΩ	0	1	0	2
10kΩ	0	1	1	3
1kΩ	1	0	0	4

Formula = Reading (as an integer) x 10^{-N} Kilohms

MODE

MODE	Pin CC	Pin DD
DC	0	0
AC	1	0
Ω	0	1

POLARITY

Polarity	Pin d	Pin e
Positive (+)	1	0
Negative (−)	0	1

AC and Ω indication is the same as positive polarity. This information is staticised.

OVERLOAD

Condition	Pin c
Not overloaded	0
Overloaded	1

PRINT COMMAND

Level: In "repetitive" (10/SEC) mode, pin v is at 0. In MANUAL pin v is at 1 except during digitisation when pin v is at 0.

Pulse: At the end of ramp down, a positive pulse (from 0 to 1) at pin u of duration 10μs.

In the instances where the voltmeter requires an extra settling time (as indicated by the WAIT light on the front), Print Command is not generated until after the required WAIT time. Thus, Print Command incorporates the WAIT facility to indicate that the display has not been updated with the result of the latest measurement.

DATA CAN CHANGE

This signal instructs the user (data system) that new Range or Mode command data can be applied.

Data Can Change	Pin x
Yes	0
No	1

GATED CLOCK

Pin k presents the clock pulses which are counted during ramp down.

OPERATING SPEED

The most important factors which govern the speed at which a data logging system can run are:

1. The delays introduced by the input scanning device.

2. The voltmeter digitisation time.

3. The time taken by the output device to record the reading.

Additionally, off-limit detection will introduce a delay.

Scanner Delays

These consists of the "sample command delay" and the "break before make gap". The sample command delay is the period between the moment a scanner relay is called and the moment sample command (Pulse or Contact Sample) is given. The break before make gap is the time between the release of one channel and the calling of the next; this is incorporated to ensure that no two channels are ever connected in parallel.

Digitisation Time

This depends on the following factors:

i) Time between start of integration and when the reading is available. For fixed range operation this time is between 40 and 80ms, depending on the reading.

ii) Internal delays introduced to give extra settling time if the commanded data is changed (10ms) or SLOW is commanded (approximately 1s).

iii) When the sample command is issued relative to the conversion cycle. On A200 and A203 integration starts only at every 5th cycle of the mains supply frequency, thus a delay of up to 100ms can occur before integration. Although A220 and A223 are not mains locked the time between integrations is the same.

iv) In addition, if AC SLOW is commanded, the sample command delay must be at least 4s to allow the input circuits to settle before a sample command is given.

Thus the maximum digitisation times for fixed range operation are:

DC FAST	⩾ 180ms*
DC SLOW	⩾ ≙1.2s
Ω FAST	⩾ 180ms*
Ω SLOW	⩾ ≙1.2s
AC FAST	⩾ ≙1.2s
AC SLOW	⩾ ≙1.2s+

*plus 10ms if commanded data is changed.

+plus 4s extra settling time that must be included in the sample command delay.

If auto ranging is used the times as given in the specification apply.

Recording Time

The time taken by an output device to record a reading may or may not affect the system speed. If the recording device has a built in staticiser (a buffer which stores the result), then the reading can be transferred almost instantaneously. This enables the voltmeter to be released for digitisation of the next measurement while the previous result is being recorded, (provided the recording time does not exceed 60ms).

More common, however, are the serial recording devices with which the time taken depends upon the number of characters to be recorded. For the recorders normally used by Solartron, the nominal times are:

Addo X Printer	55ms per character +350ms
Clary 35 Printer	60ms per character +150ms
IBM 'B' Typewriter	100ms per character +500ms approx. per new line
ASR 33 Teleprinter	100ms per character
Addo 5 Punch	55ms per character
Facit 4070 Punch	13.3ms per character
DD110 Punch	9ms per character +9ms
RDL 10000 Tape Recorder	1ms to 2.5ms per character (depending on packing density)

HIGH SPEED REMOTE CONTROL

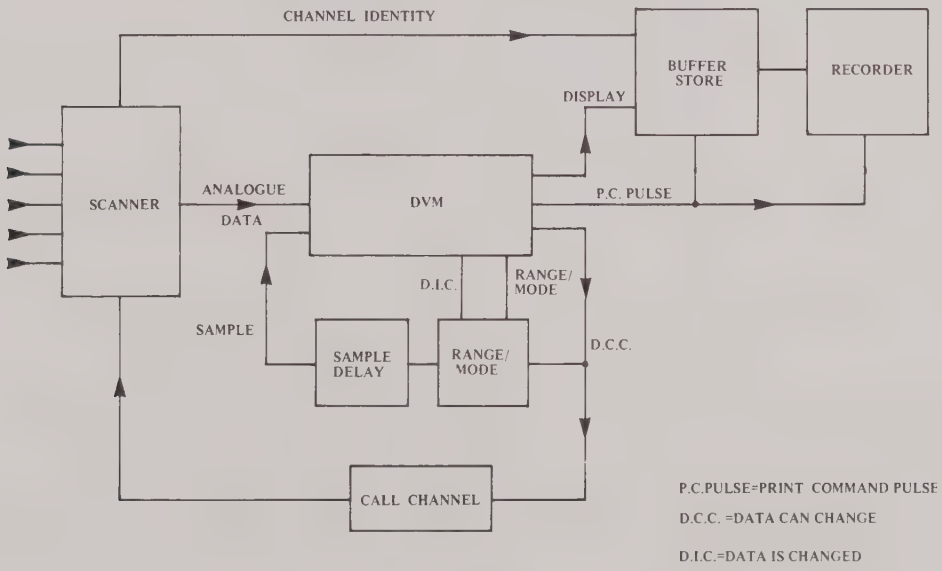


Fig. 5.1 Basic Logging System

Figure 5.1 shows a typical arrangement of a digital voltmeter (dvm) controlled externally in a data logging system. In this example, the recording device must be capable of completing the record within 60ms so that the system can operate at 10 channels per second, the fastest possible recording speed. The dvm measures sequentially the voltages from a number of input channels. The range and mode information is pre-programmed and may change from one channel to the next.

The operation is as follows: with the first channel connected to the dvm a sample is manually initiated (by either the MANUAL button or CONTACT SAMPLE for example); PRINT COMMAND goes low (DATA CAN CHANGE goes high) and the dvm measures the input starting at the first available complete conversion cycle. At the end of measurement the following occurs:

i) PRINT COMMAND goes high to initiate the transfer of the display information into the buffer/store.

ii) DATA CAN CHANGE goes low a) to enable a Range and/or Mode change if it is required, b) to command the application of the next channel.

If the new Range and/or Mode is different from the previous measurement DATA IS CHANGED must be taken high to increase the internal delay thereby giving the extra settling time required.

When the next channel is connected the sample delay is initiated. This delay ensures that the scanner relay contacts have settled. At the end of the sample delay PULSE SAMPLE is generated to instruct the dvm to start measurement of the new channel.

The timing of these events, shown in figure 5.2, is critical and is governed by the following rules:

i) PULSE SAMPLE: This must occur not earlier than 5ms after selection of range/mode/channel whichever is the latest.

For the highest recording rate (10 channels per second) the latest time that PULSE SAMPLE can be generated (assuming the worst case when the previous reading was full scale) is:

either approximately 10ms(*) after PRINT COMMAND (and DATA CAN CHANGE) if DATA IS CHANGED is high (data changed)

or is approximately 19ms(*) after PRINT COMMAND (and DATA CAN CHANGE) if DATA IS CHANGED is low (data not changed).

* The exact period is determined by the clock frequency which for A200 and A203 is fixed by the mains supply frequency.

Hence the sample delay must be >5ms and the break before make gap plus the sample delay must not exceed 10ms (or 19ms).

If AC and SLOW are commanded the sample delay must be increased by 4s to allow sufficient settling time.

ii) DATA IS CHANGED: This command must be applied after PRINT COMMAND has gone high (DATA CAN CHANGE has gone low) and before PULSE SAMPLE, and must be maintained until DATA CAN CHANGE next goes low.

Normally, as in the system described, DATA IS CHANGED would be coincident with the new channel selection.

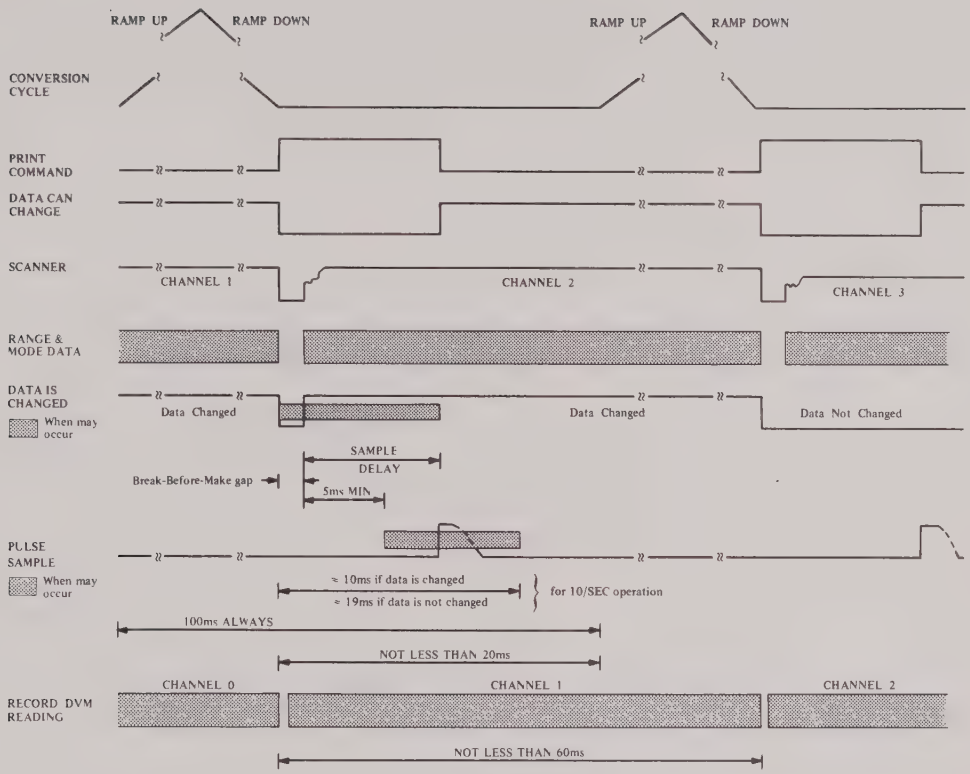


Fig. 5.2 Timing

SECTION 6 Principles of Operation

DUAL RAMP

The basic measuring circuit used in these instruments is a bipolar analogue to digital converter operating on the dual ramp principle.

In this technique the unknown input is caused to charge a capacitor for a fixed time. Then, with the unknown removed, a reference voltage is used to discharge the capacitor. The time taken to discharge the capacitor is a measure of the unknown. To ensure that the charge and discharge are linear an integrator is used.

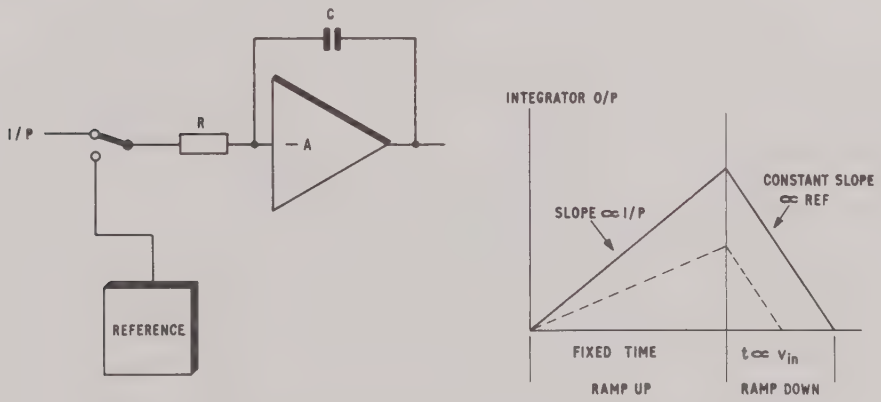


Fig.6.1 Basic Principle

When the integrator is connected to the input its output 'ramps up' at a rate which is directly proportional to the value of the input. After a fixed time the switch changes over and connects the reference in place of the input. It is arranged that the reference voltage is of opposite polarity to that of the input, so that the integrator output now 'ramps down' at a fixed rate which is determined by the value of the reference. The time taken to 'ramp down' is a direct measure of the unknown. The ramp up time can be defined and the ramp down time measured by the arrangement shown below.

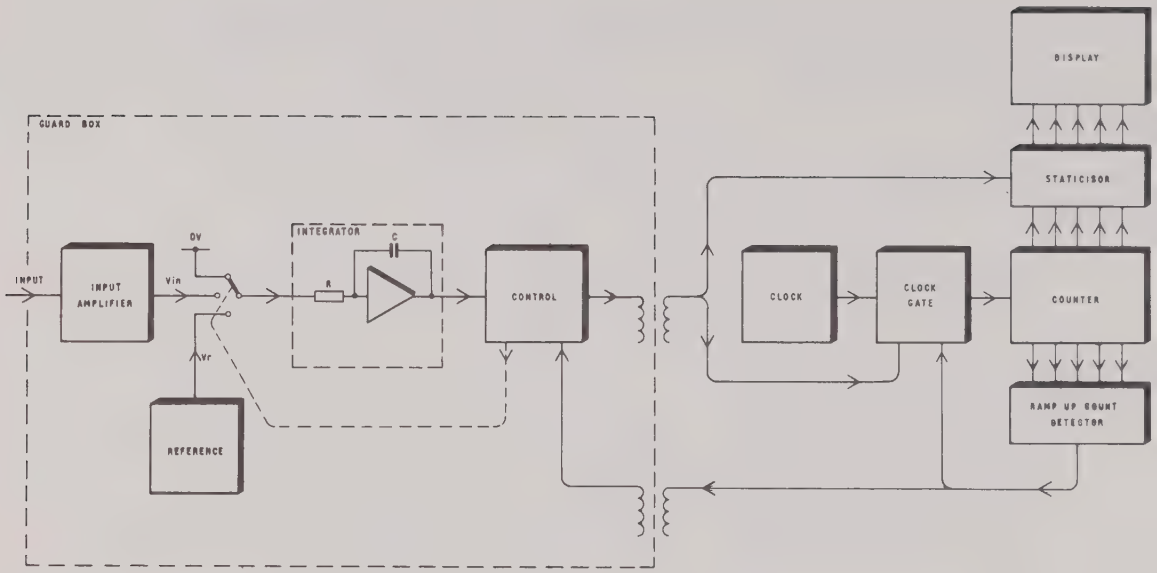


Fig.6.2 Basic Dual Ramp Block Diagram

A measurement cycle is started by the control switching the integrator to the input. At the same time the counter is set to zero and the gate opened. Pulses from the clock then accumulate in the counter while the integrator output rises as a ramp. If the counter has a "full house" of 19999, then the 20000th pulse will return it to zero. It is arranged that when the 20000th pulse is entered, the output pulse generated as the counter resets, causes the control to disconnect the integrator from the input. Ramp up is thus terminated after a period dependent upon the clock frequency and the counter "full house"; a 500kHz clock giving a nominal ramp up time of 40ms.

At the end of ramp up, a voltage (V_1) will have been stored on the integrator capacitor. This voltage is

$$V_1 = \frac{VinT_1}{CR} \quad volts \qquad (1)$$

where:- Vin = input voltage

T_1 = ramp up time

C and R are the integrator components

The reference (of opposite polarity to the input) is now connected to the integrator which begins ramp down towards zero at a rate proportional to the reference. Meanwhile, clock pulses are still being applied to the counter, which started from zero again as ramp down commenced.

When the ramp reaches zero the gate closes and the control causes the reference to be disconnected from the integrator. Hence ramp down is terminated.

The number of pulses in the counter is directly related to the time taken for ramp down and, because the reference voltage is constant, it is also proportional to V_1 which was stored at the end of ramp up.

If, during ramp down, the integrator output at time t is V_2 and the reference voltage is Vr, then:

$$V_2 = V_1 - \frac{Vr\,t}{CR} \text{ volts} \qquad (2)$$

and after T_2 (ramp down time) when $V_2 = 0$ then:

$$V_1 = \frac{Vr\,T_2}{CR} \text{ volts}$$

Hence, from (1) and (2)

$$\frac{VinT_1}{CR} = \frac{VrT_2}{CR}$$

$$\therefore \; Vin = Vr\,\frac{T_2}{T_1} \text{ volts}$$

Now the number (N) of clock pulses accumulated in the counter for a clock frequency of fHz is:-

$$N = T\,f \text{ pulses}$$

Thus $$T = \frac{N}{f} \text{ seconds}$$

$$\therefore \; Vin = Vr\,\frac{N_2}{f} \cdot \frac{f}{N_1}$$

$$Vin = Vr\,\frac{N_2}{N_1}$$

But Vr and N_1 are constant, therefore

$$Vin \propto N_2$$

and is independent of clock frequency.

Thus the number of pulses accumulated by the counter during ramp down is directly proportional to the voltage being measured.

The *MASTER SERIES* of instruments operate basically as described but with certain refinements which significantly improve both accuracy and series mode rejection.

1) In the A200 and A203 only, a digital servo system continuously monitors the 50Hz mains frequency and, by modifying the clock frequency, ensures that ramp up lasts for exactly two mains periods.

2) A 4μs delay is introduced between the end of the ramp up period and the beginning of ramp down. This allows time for the correct polarity reference to be selected and prevents the possibility of inaccuracies due to switching transients.

3) After completion of ramp down, which can last for up to 40ms, a minimum of 20ms is available before the start of a new measurement for drift correcting the integrator (A200, A203, A220 and A223) and frequency adjusting the clock (A200 and A203 only).

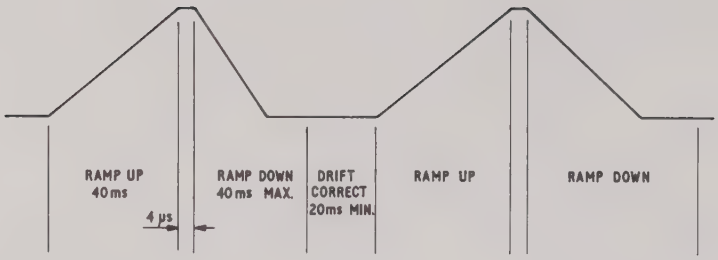


Fig.6.3 Sequence of Operation

DC MEASUREMENT

For dc measurement the integrator is preceded by an input amplifier using feedback. This arrangement increases the input impedance of the voltmeter and facilitates range switching.

AC MEASUREMENT

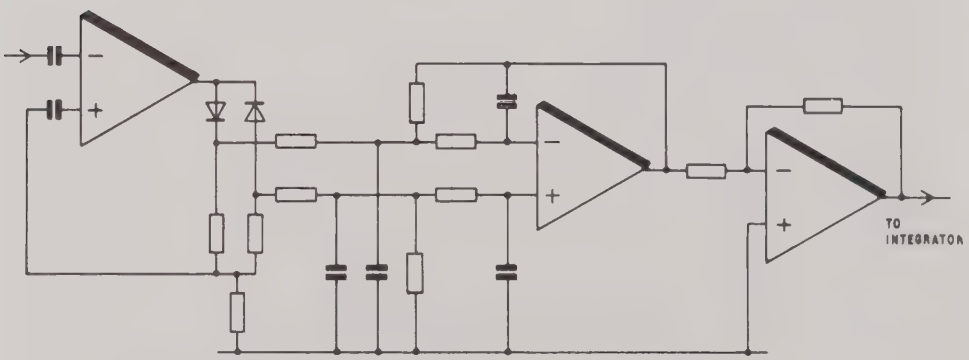


Fig.6.4 AC Measurement

For measurement of ac, the integrator is preceded by an operational rectifier, followed by a filter and an amplifier to obtain a dc signal referred to a common 0V. This dc signal is proportional to the mean rectified ac signal and is scaled by a factor of 1.11, to represent the rms value of a sine wave input, before being applied to the integrator. Thus, the ac is continuously converted to dc for subsequent application to the integrator. Ranging is effected by an input attenuator.

RESISTANCE MEASUREMENT

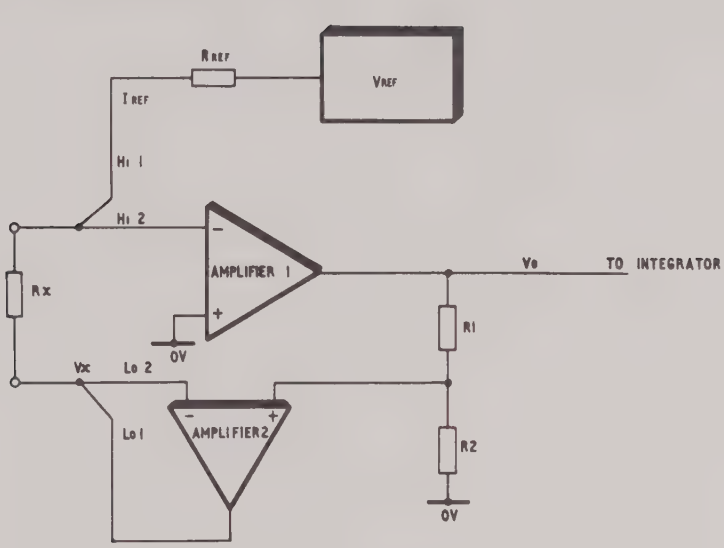


Fig. 6.5 Resistance Measurement

Basically, resistance is measured by measuring the potential developed across the unknown resistor when a known reference current is passed through it.

In the system of resistance measurement used in the A203 and A223, great care has been taken to minimise errors caused by lead resistance. A four terminal technique is used, two terminals apply the reference current whilst two terminals sense the potential difference across the resistor. However, on the standard input lead the connection of the sense leads to the supply leads is effected inside the cable.

Rx, the resistance being measured, is made part of the potential divider comprising R_{REF} and Rx. This divider is connected between V_{REF} and the output of voltage follower Amplifier 2. The output (Vx) of Amplifier 2 is proportional to the output (Vo) of Amplifier 1. Amplifier 1 senses the potential at the junction of R_{REF} and Rx.

At equilibrium, Vx will be such that the voltage at Hi 2 is the input amplifier error voltage which is very nearly zero.

Then $$\frac{V_{REF}}{R_{REF}} = \frac{Vx}{Rx}$$

Since Vx is proportional to Vo then $Vo \propto Rx$

The lead resistance of Hi 1 cannot cause an error because R_{REF} is always large enough (9.9k, 99k or 9.9M) to 'swamp' the usual level of lead resistance.

The resistance of Lo 1 will not cause an error because the action Amplifier 2 is to define, at the junction of Lo 1, Lo 2 and Rx, the same potential as exists at the junction of R1 and R2. Thus the voltage caused by the reference current flowing through the Lo 1 lead resistance appears only across Amplifier 2 and has no effect on the measurement.

The resistance of lead Hi 2 and Lo 2 will have no effect on the measurement because the only current flowing along these leads is amplifier input current, which is so small as to be insignificant.

SECTION 7 Circuit Description & Servicing Information

List of Sub-Sections

Title	Sub-section
DC Input (without AC, Ω)	7.1
DC Input (with AC, Ω)	7.2
AC Input	7.3
Ω Input	7.4
Input Amplifier Connections	7.5
Input Amplifier (1μV)	7.6
Input Amplifier (10μV)	7.7
Floating Relays	7.8
Range and Mode Logic (with Auto range)	7.9
Auto Range Logic	7.10
Range and Mode Logic (without Auto range)	7.11
Integrator	7.12
Integrator Control Logic	7.13
Control Logic	7.14
Divide by Five and Clock	7.15
Counter and Display	7.16
Power Supplies	7.17
Systems Interface (Fan-out)	7.204

Introduction

This section, which constitutes the complete circuit description for all the instruments of the series, is arranged in several sub-sections.

The first sub-section (pages 7(i) to 7(xi)) is an overall description of the instruments and also serves as an introduction to the later sub-sections.

Each of the following sub-sections is a detailed description of a particular functional part of the instrument and is based on its circuit diagram, which is found on the final page.

The page numbering system follows that of the circuit diagrams, all information relating to a circuit diagram being found on pages with the same number prefix as the diagram.

Figure 7.1 is a cross-reference chart which also serves as an index to the sub-section. This chart will be found useful if consulted as a peparatory step to circuit investigation. It should be used in conjunction with the Key diagram Fig. 7.6, when it will quickly enable the reader to establish the circuit diagrams which need to be consulted for the model under investigation. It will also show him which pcb's are covered by each diagram.

OVERALL CIRCUIT DESCRIPTION

This description must be read in conjunction with Fig. 7.6 the Key diagram. It is also assumed that the reader is familiar with the contents of Section 6, "Principles of Operation".

Fig. 7.6 is a block diagram applicable to all instruments in the series. Each block is numbered, the number corresponding to the circuit diagram concerned. For instance see block "14 CONTROL LOGIC". The circuit for this block is No. 14 and all relevant information on this block will be found on pages 7.14.1 to 7.14.6. Reference to Fig. 7.1 the "Cross-reference Chart" shows that this diagram applies to all models and contains major parts of pcb's 9, 25 and 36.

If Fig. 7.6 is studied after reading Section 6 it will be found to be mainly self-explanatory. For clarification the following points are examined in greater detail.

THE INTEGRATOR (CIRCUIT DIAGRAM No. 12)

This is the heart of the instrument and its theory is covered in detail in Section 6. The input to this block is a dc voltage proportional to the dvm input (whether dc, ac or ohms) and scaled to 6.4V = 19999 clock pulses, (1 clock pulse = 320μV approx.).

The output of this block is polarity (dvm input – or +) during ramp up and "end of ramp down" signifying that the ramp down has reached zero.

THE FLOATING BOX

Input selection and scaling, the Integrator and its control are all contained in an electrically isolated guard box. All supplies into this box are via magnetic coupling, either by relays or transformers. Selection is by relays, the coils being located in the earthy section and the contacts in the floating box. Signals to and from the integrator are by pulse transformer (toroids).

CONTROL LOGIC (CIRCUIT DIAGRAM No. 14)

This circuit provides the timing for the instrument. It starts the ramp-up and detects the polarity from the Integrator; then, after the required time, ends the ramp-up and starts the ramp-down. It then detects the end of ramp-down and commands the display to show the polarity and the count. These are the "Statistise" commands.

MODEL VARIATIONS

This manual applies to seven models of dvm and two display systems. All models consist of the same Mainframe and the following pcb's:- 3, 4, 5, 6, 9, 11, 12, 22, 23, 25, 26 and 36 together with either 7 or 46 and 47.

The various models are assembled by fitting alternative additional pcb's and the applicable front panel. Table 7.1 shows the appropriate pcb's which are added to the above Basic Assembly to form the various models.

TABLE 7.1

		Model		Model
Basic Assembly	+ pcb 2 (A200), pcb 8 (A200), pcb 10 (A200), pcb 31	= A200	−pcb 31 + pcb 14, pcb 15, pcb 16	= A203
			−pcb 31 + pcb 41, pcb 15, pcb 16	= A205
	+ pcb 2 (A220), pcb 8 (A220), pcb 10 (A220), pcb 31	= A220	−pcb 10 (A220) +pcb 10 (A200)	= A227
			pcb 31 + pcb 14, pcb 15, pcb 16	= A223
			−pcb 31 + pcb 41, pcb 15, pcb 16	= A225

It should be noted that there are two versions of pcb's 2, 8 and 10 and care should be exercised when ordering or fitting replacements for these boards that the correct type No. is used.

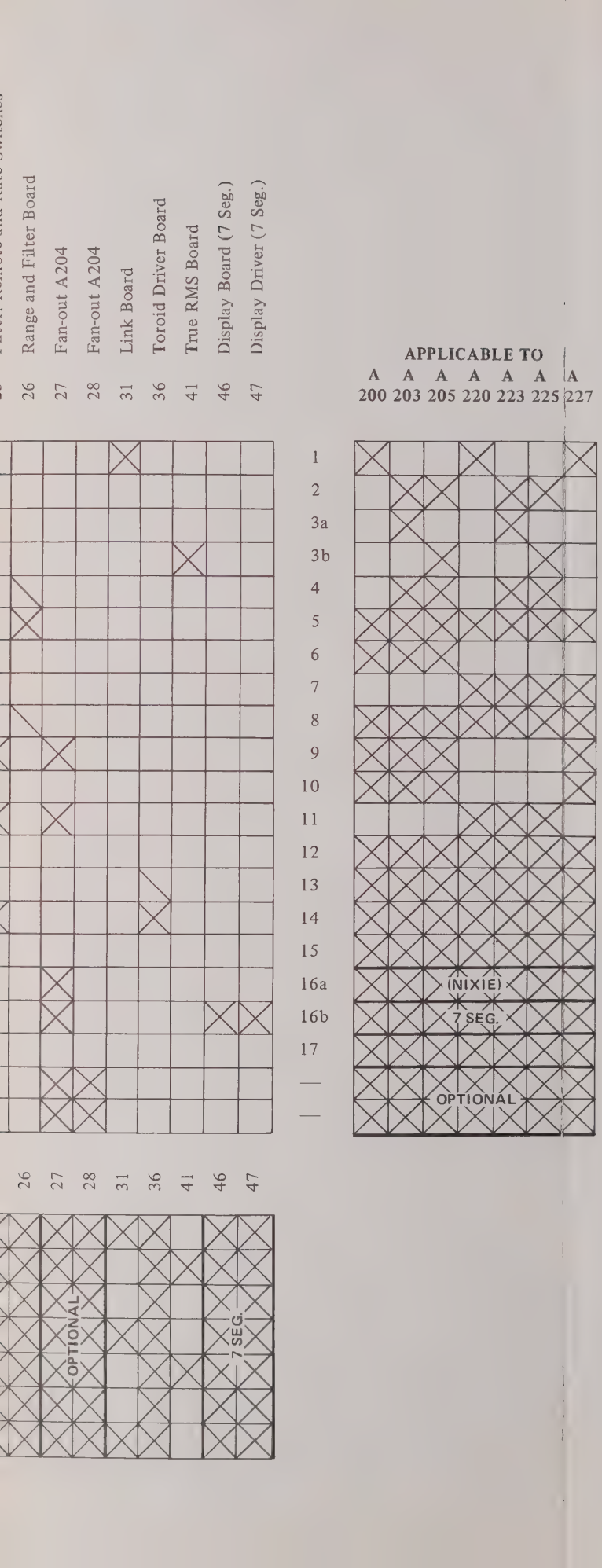
The System Interface (A204) consisting of pcb's 27 and 28 can be fitted to all models.

CIRCUIT DIAGRAMS

Sections 7 to 9 were initially prepared before the introduction of models A205, A225 and A227 and before the introduction of the seven bar display. For this reason some of the references and annotations may be incomplete. If any doubt exists a check should be made with the Cross Reference Chart (Fig. 7.1). For example, circuit diagram No. 9 is labelled "(A200 and A203)" whereas Fig. 7.1 shows that it also applies to the A205 and A227.

CIRCUIT	
DC Input, (No AC, Ω)	1
DC Input, (AC, Ω)	2
AC Input (Mean Sensing)	3a
AC Input (True RMS)	3b
Ohms Input	4
Input Amplifier Connections	5
Input Amplifier (1μV)	6
Input Amplifier (10μV)	7
Floating Section Relays	8
Range and Mode Logic	9
Auto Range Logic	10
Range and Mode Logic	11
Integrator	12
Integrator Control Logic	13
Control Logic	14
Divide by 5 and Clock	15
Counter and Display (Nixie)	16a
Counter and Display (7 Seg.)	16b
Power Supplies	17
A204 Systems Interface (Sh.1.)	—
A204 Systems Interface (Sh.2.)	—

APPLICABLE TO A200 A203 A205 A220 A223 A225 A227		PRINTED CIRCUIT BOARDS
	2	A200 Input Amplifier
	2	A220 Input Amplifier
	3	Integrator and Reference
	4	Toroid Receiver and Logic
	5	Floating PSU and FET Drivers
	6	Floating Mother Board
NIXIE	7	Display Board (Nixie)
	8	A200 Control Discrete Circuits
	8	A220 Control Discrete Circuits
	9	Control Logic (Earthy)
	10	A200 Mode and Range Logic
	10	A220 Mode and Range Logic
	11	Counter Logic
	12	Earthy Power Supply
	14	AC Converter
	15	AC Auxilliary Board
	16	Ohms and AC Filter Board
	22	Earthy Power Supply
	23	Range and Mode Switches

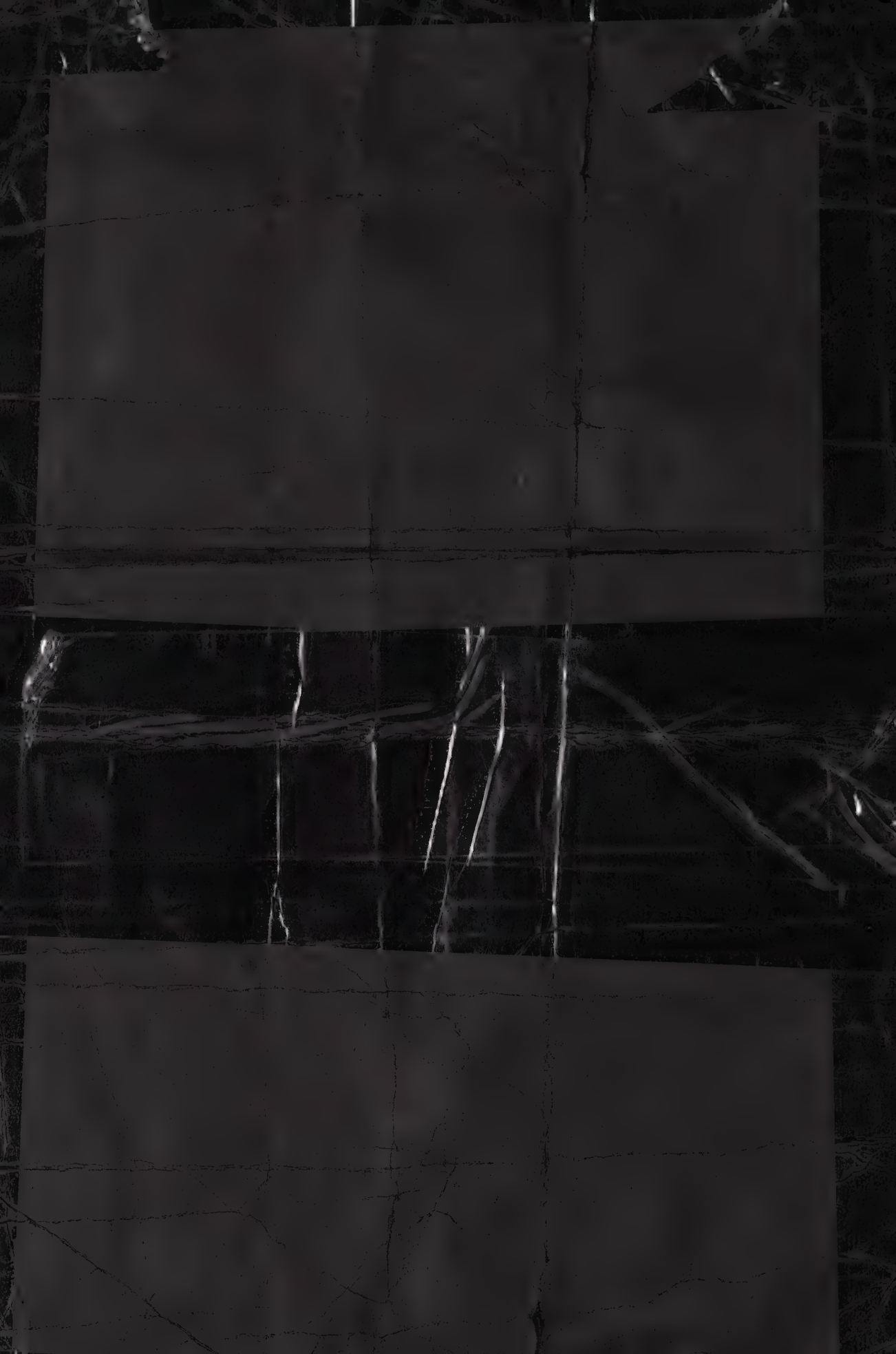


A200 Circuit Diagram/Printed Circuit Board Cross Reference Chart

This chart lists the pcb's horizontally and the circuit diagrams vertically. If the circuit diagram contains a significant amount of detail, the correlation between them is down by an intersecting cross. If the correlation is of a minor nature it is shown by a stroke.

The applicability tables to the right and beneath the main chart indicate the dvm models affected. The right hand chart shows the allocation of circuit diagrams and the lower the allocation of pcb's for each model.

Fig. 7.1 Cross-reference Chart



KEY DIAGRAM

The Key Diagram (Fig. 7.6) appears at the end of this sub section.

This diagram presents a visual Key as to how the **Functional Circuit Diagrams**, numbered **1 to 17**, together with **Fan Out Sheets 1 and 2** are linked together.

Notation of signals and commands on the Key Diagram appear on the Circuit Diagrams as flagged indications of inputs and outputs.

The numbers in the blocks refer to the functional drawings comprising **Section 7**.

In the general description which follows references to models A200 and A203 should also include the A205 and references to A220 and A223 should include the A225. See also under the heading "**Circuit Diagrams**".

The **Input Mode, DC (1 or 2), AC (3) and Ω(4)** is selected by commands from either **Range and Mode Logic (9)**, A200 and A203 or **Range and Mode Logic (11)**,A220 and A223. Commands are initiated either by operating the front panel controls of range and mode, or by remote commands in logic levels (TTL Compatible) to the **A204 Fan Out** (see Section 6, Remote Commands).

Commands are transferred to the Floating Section via Relay Coils A, B, D and E (DC Ranges and Filter; all instruments) and F, H, J and K (AC Ranges and Filter; Ω Mode; A203 and A223 only). This is shown in **Floating Section Relays (8)**.

In DC Mode, the amplifier shown in **Input Amplifier Connection (5)** is range scaled so that the same FSD output voltage is applied to the **Integrator (12)**.

The **Input Amplifier (6 or 7)** has a high open loop gain necessary for accurate scaling and, because the input signal forms part of the amplifier feed back loop, a very high input resistance, required for accurate measurement is achieved. See 'High Accuracy Digital Voltage Measurement', DVM Monograph No.8, for further discussion.

In AC Mode, the applied ac is first attenuated, then converted to dc and finally filtered and applied as a 1V (FSD) signal to the Input Amplifier; refer to **Input Amplifier Connection (5)**. which is set to the 1V DC Range.

For Ω Mode, refer to Fig.6.5 and **Ω Input (4)**. The unknown resistance is measured by passing a known reference current through it and applying the voltage developed to the **Input Amplifier (6 or 7)**, scaled for resistance as in **Input Amplifier Connection (5)**. In Fig.6.5, Amplifier 1 is the Input Amplifier and Amplifier 2 is voltage follower shown in **Ω Input (4)** which ensures that the voltage in Lo 1 produced by the reference current is not added to the voltage across the unknown resistor.

The timing of events is derived from the mains frequency in the **Power Supply (17)**. The **Divide by 5 and Clock (15)** sets the 10Hz reading rate (12Hz from 60Hz Mains) and provides the 500kHz clock frequency (600kHz from 60Hz mains). In the A200 and A203, the clock frequency is adjusted during the drift correct period so that Ramp up lasts for exactly two mains periods.

The Integrator (12) compares the scaled amplifier output, switched during ramp up, with either the positive reference (for negative integrator input positive dvm inputs) or the negative reference (positive integrator input, negative dvm inputs), switched during ramp down. The ramp up time is 19999 clock pulses (40ms or 2 mains periods), ramp up being commanded at the start of the measuring cycle from the Ramp Up Bistable in **Control Logic (14)**. At this time the Counter in **Counter and Display (16)** is set to zero, the Counter Clock Gate opens passing clock pulses to the Counter. On the 19999th pulse the integrator capacitor, C14, in Integrator (12) will have charged to a value proportional to input voltage (approximately 11.4V for a "full house" dvm input). The 20000th pulse returns the counter to zero, ramp up ends and the scaled amplifier output is disconnected from the integrator. Polarity decision of the dvm input is made and the correct reference polarity selected. 4μs after the end of ramp up, ramp down is commanded from the **Control Logic (14)**, and the correct reference voltage switched to the Integrator Input.

The Counter Clock Gate, however, is not opened until 12μs after the start of ramp down, when the ramp down slope is linear. To correct for this, a small offset is applied to the Comparator, in **Integrator (12)**, to allow ramp down to continue beyond zero before end of ramp down is detected. When end of ramp down is detected, it is signalled from the Integrator to **Control Logic (14)** via **Integrator Control Logic (13)**. The Counter Clock Gate is closed, the Ramp Down Bistable commands end of ramp down and commence drift correct to the Integrator. 8μs later, the number stored in the Counter in **Counter and Display (16)** is clocked to the Display Tubes, i.e. staticised by a clock pulse; "Staticise Data" from **Control Logic (14)**.

This value is the digital conversion of the analogue input to the instrument.

For a "full house" input, ramp down will be 40ms (50Hz mains), the 500kHz (600kHz from 60Hz mains) clock pulses producing a count of 19999 in the Counter.

Drift correct is approximately 20ms for a 19999 reading. During drift correct, the offset charge on the integrator capacitor C14, produced by ramp down continuing beyond zero, is feed back to the integrator input via the drift correct capacitor C15. This ensures that the integrator capacitor is fully discharged to zero by the time the next measuring cycle commences.

The **A204 Fan Out** enables both remote operation of the dvm and the transfer of displayed data to a recording system.

CAUTION : EXTRACTION OF PCB's

Careless extraction of PCB's could damage the edge connectors. They should always be extracted evenly from the edge connector socket and NOT by pivoting about one corner.

ACCESS TO PCB's

1) Release side panel bracket screws located left and right of the rear panel.

2) Remove the side panels by extracting from the back of the instrument.

3) Top and Bottom panels may now be removed by sliding back to clear the rear panel.

For calibration, the top panel only need be removed, and then only sufficiently for access to the appropriate adjustment.

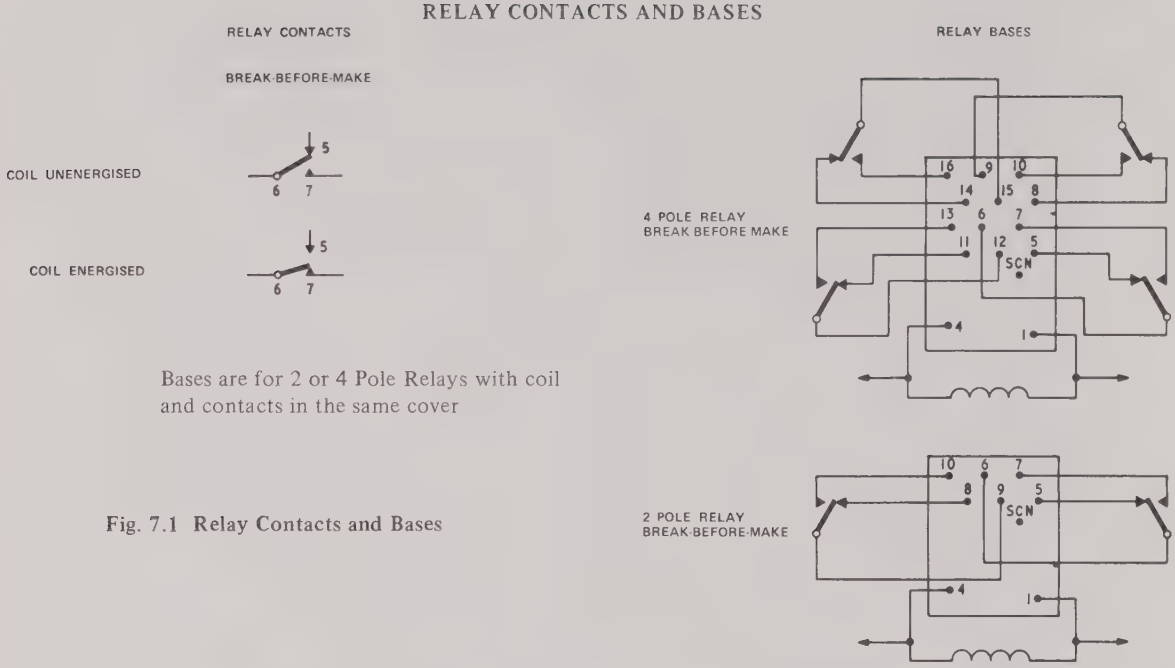
EXTENSION BOARD KIT AND 1C PIN CLIP

The use of EX3188 Extension Board Kit is recommended for efficient pcb access.

Extension Board Nos.		DVM Board Nos.
A2009032, 32 Way	for	Boards 8 and 11
A2009033, 44 Way	for	Boards 2,3,4,5,7,14 and 16.
A2009037, 24 Way	for	Board 10
A2009038, 16 Way	for	Board 9
A2009039, 24 Way	for	Fan Out A204.

The use of a **Dual In Line IC Clip, 16 Pin**, such as that supplied by Electronic Component Supplies Limited, Thames Avenue, Windsor, Bucks, is recommended for checking IC pin voltages.

RELAY CONTACTS AND BASES



Bases are for 2 or 4 Pole Relays with coil and contacts in the same cover

Fig. 7.1 Relay Contacts and Bases

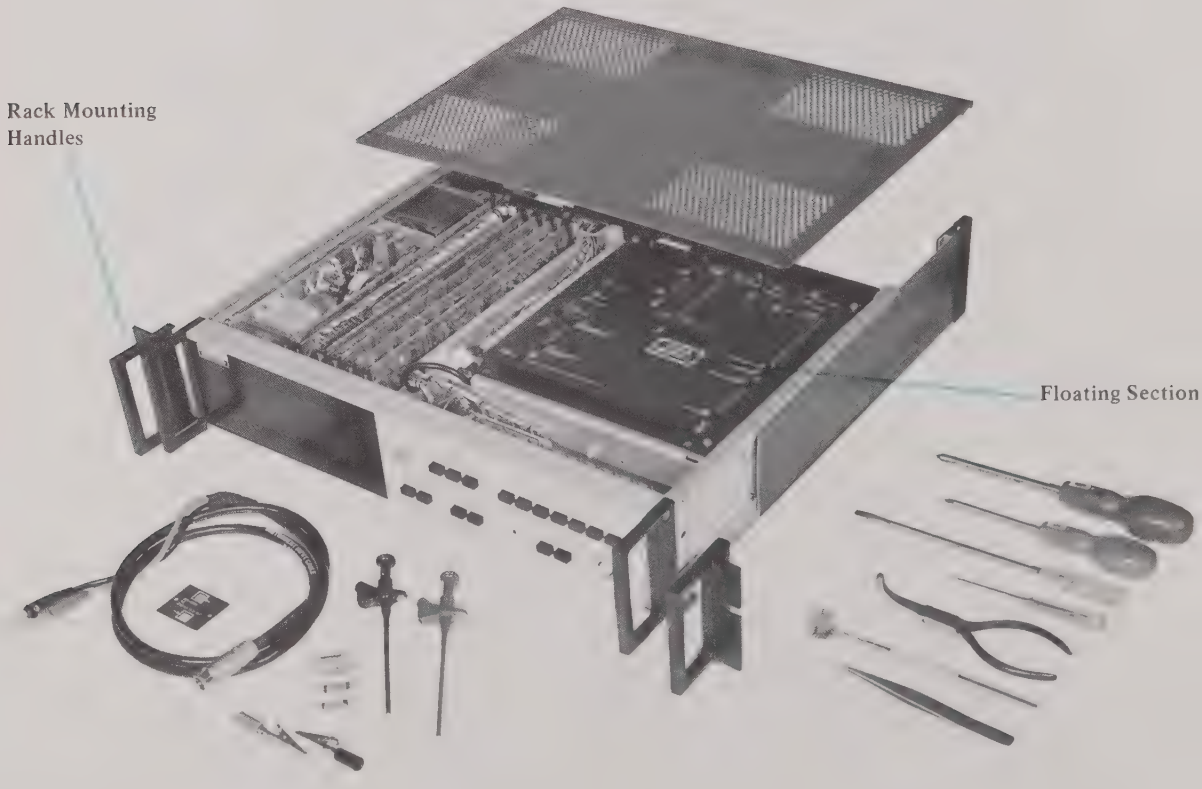


Fig. 7.2 Removal of Top and Side Panels

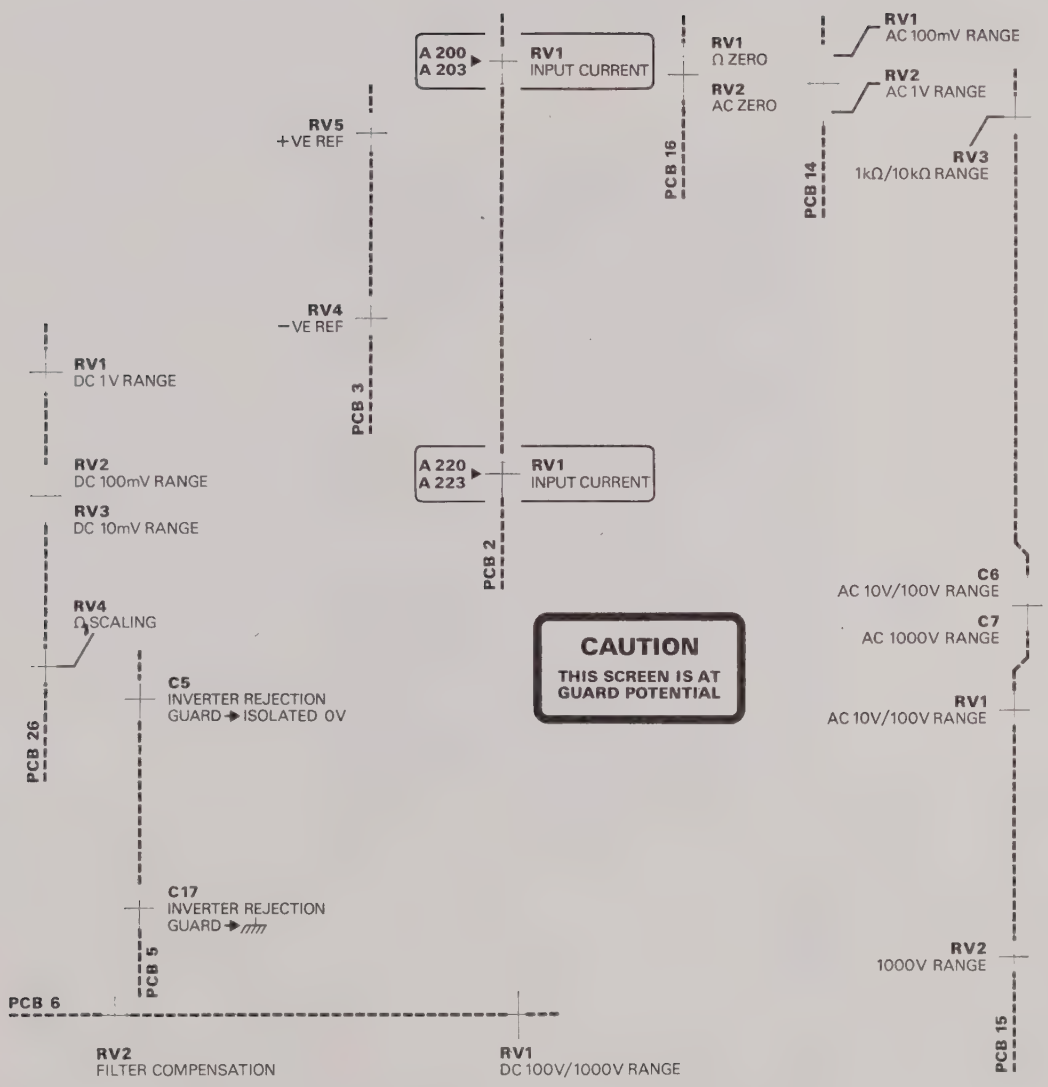


Fig. 7.3 Floating Section Cover

Remove the four corner screws for access to the floating section

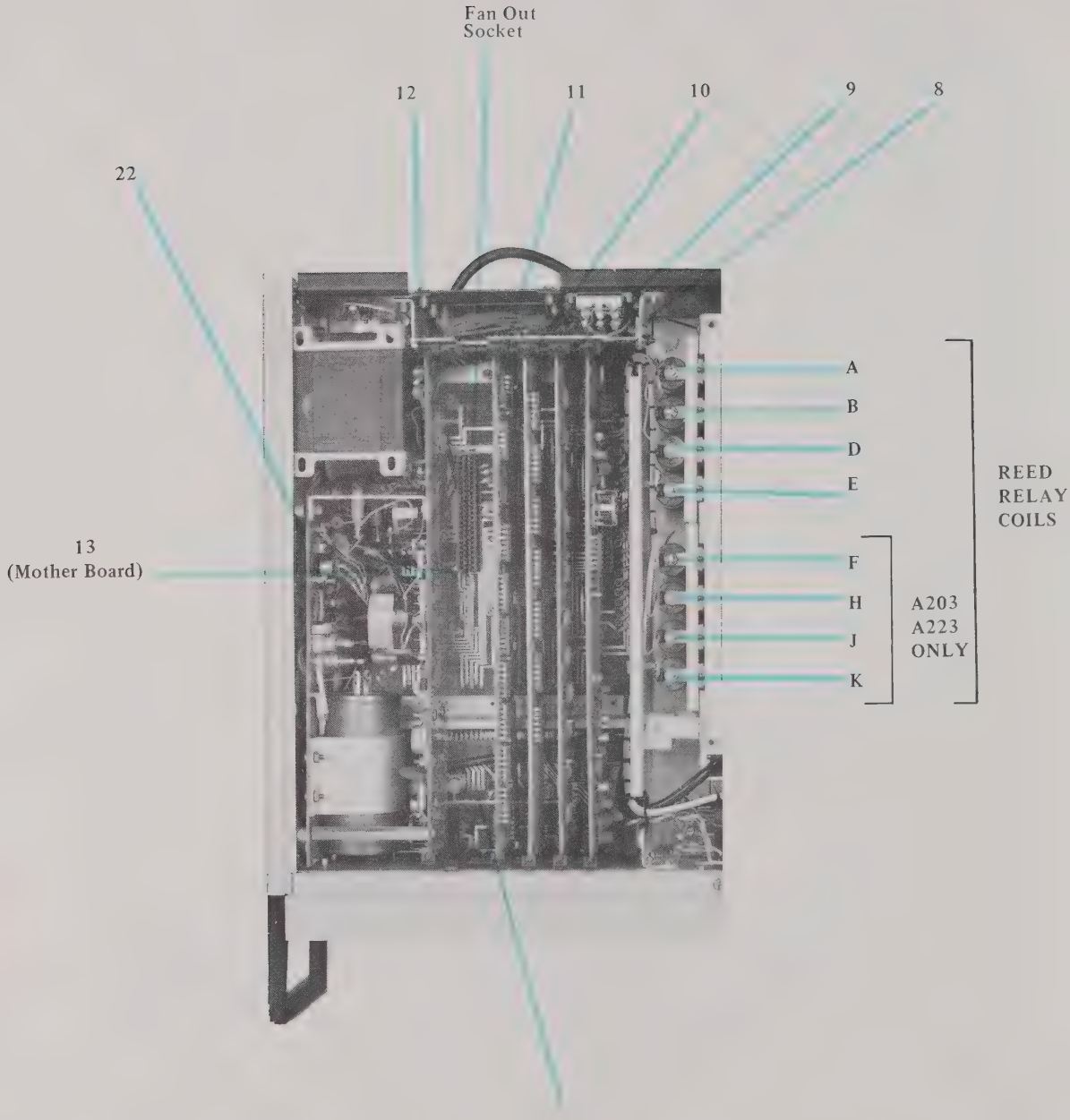


Fig. 7.4 Earthy Section Pcb Location

Pcb's 8, 9, 10, 11 and 12 are secured by clips. Pcb 22 is bolted to the left hand frame by 4 screws.

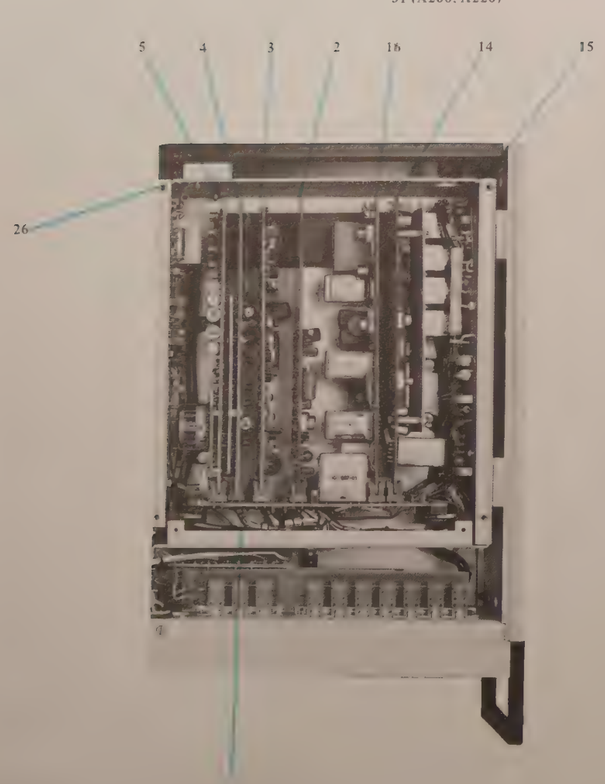


Fig. 7.5 Floating Section Pcb Location

Pcb 6 is free to pivot up with Pcb's 5, 4, 3, 2, 1b (31 on A200 and A220) and 14 attached by plug and socket connection.

This must be done with care using both hands and supporting each board.

To remove the boards, support Pcb 6 as shown in Fig. 7.31 (DRG 5 refers)

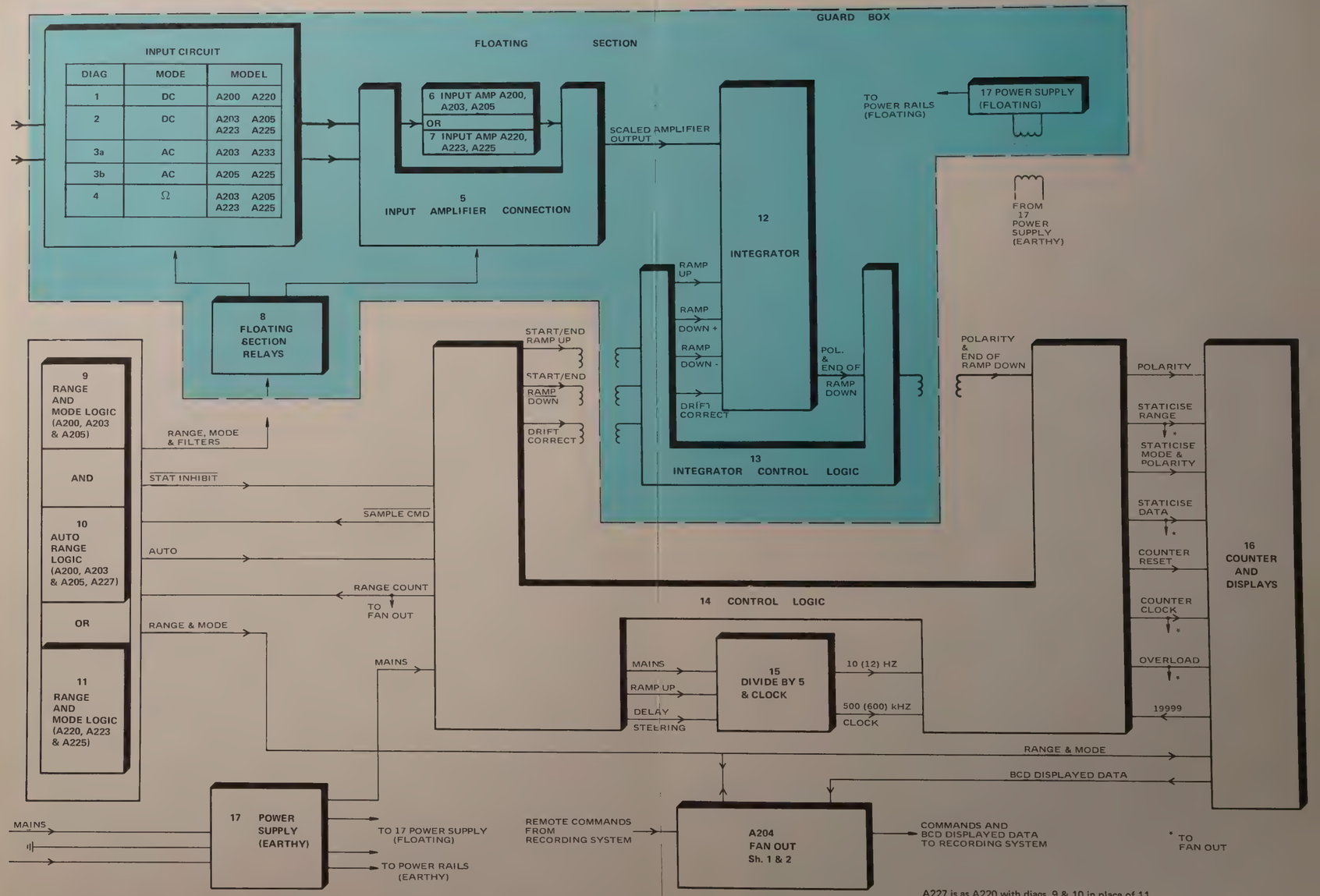
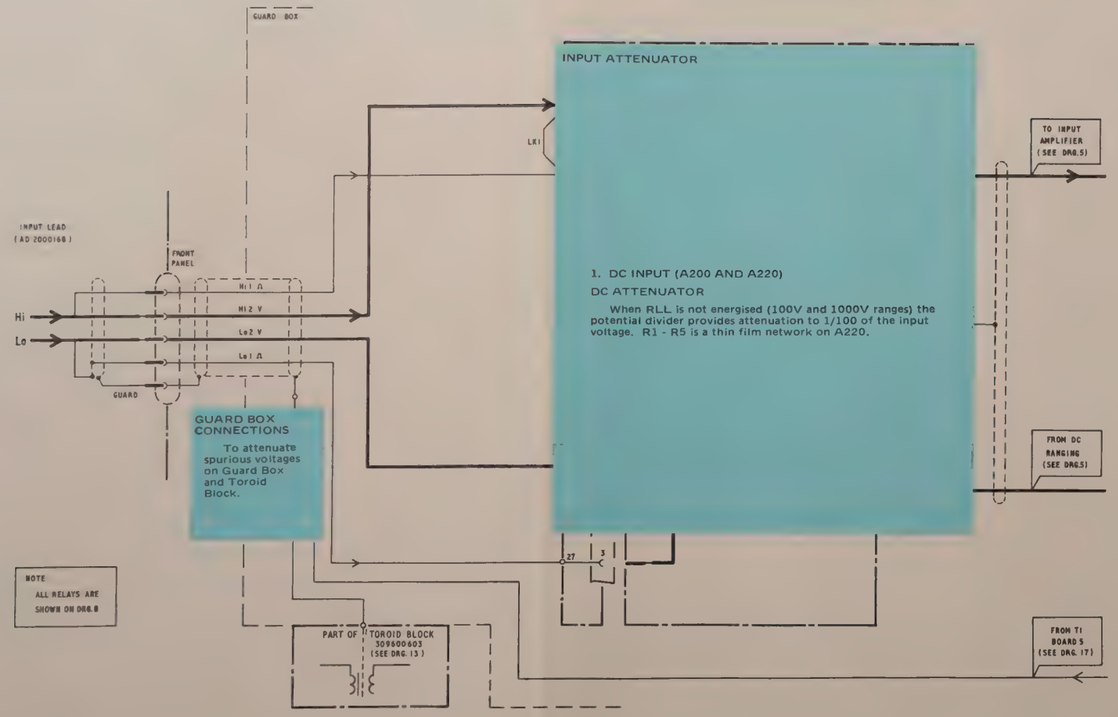


Fig. 7.6 KEY DIAGRAM

PART OF FLOATING SECTION


GUARD BOX
INPUT ATTENUATOR
LK1
TO INPUT AMPLIFIER (SEE DRG.5)
INPUT LEAD (AD 2000168)
FRONT PANEL
Hi 1 Ω
Hi 2 V
Lo 2 V
Lo 1 Ω
Hi
Lo
GUARD
1. DC INPUT (A200 AND A220)
DC ATTENUATOR
When RLL is not energised (100V and 1000V ranges) the potential divider provides attenuation to 1/100 of the input voltage. R1 - R5 is a thin film network on A220.
GUARD BOX CONNECTIONS
To attenuate spurious voltages on Guard Box and Toroid Block.
FROM DC RANGING (SEE DRG.5)
27
3
NOTE
ALL RELAYS ARE SHOWN ON DRG.8
PART OF TOROID BLOCK 30900603 (SEE DRG.13)
FROM T1 BOARD 5 (SEE DRG.17)

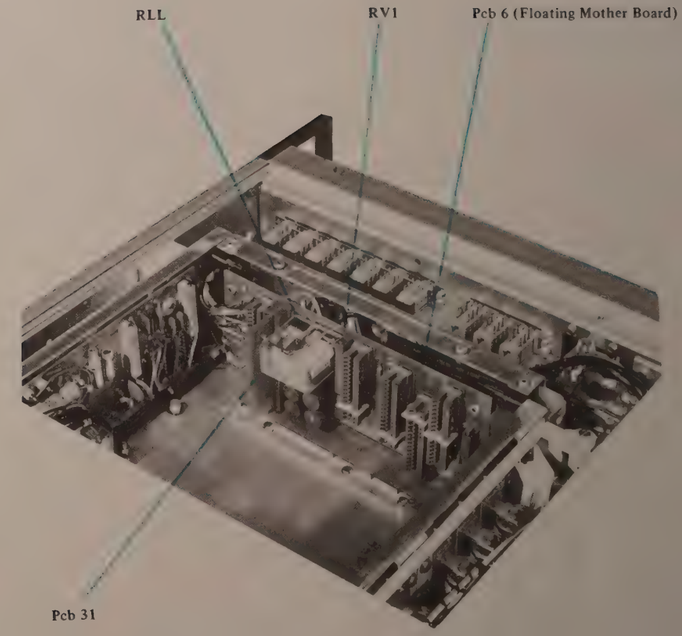


Fig. 7.7 Pcb 6, Pcb 31

DC INPUT (A200 AND A220) DESCRIPTION 1

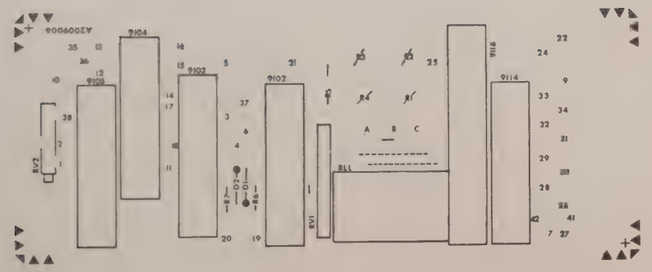


Fig. 7.8 Pcb 6 (Component Side)

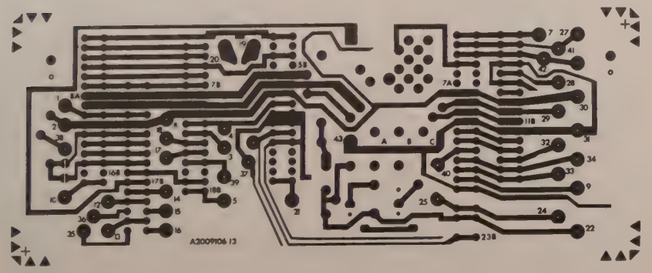
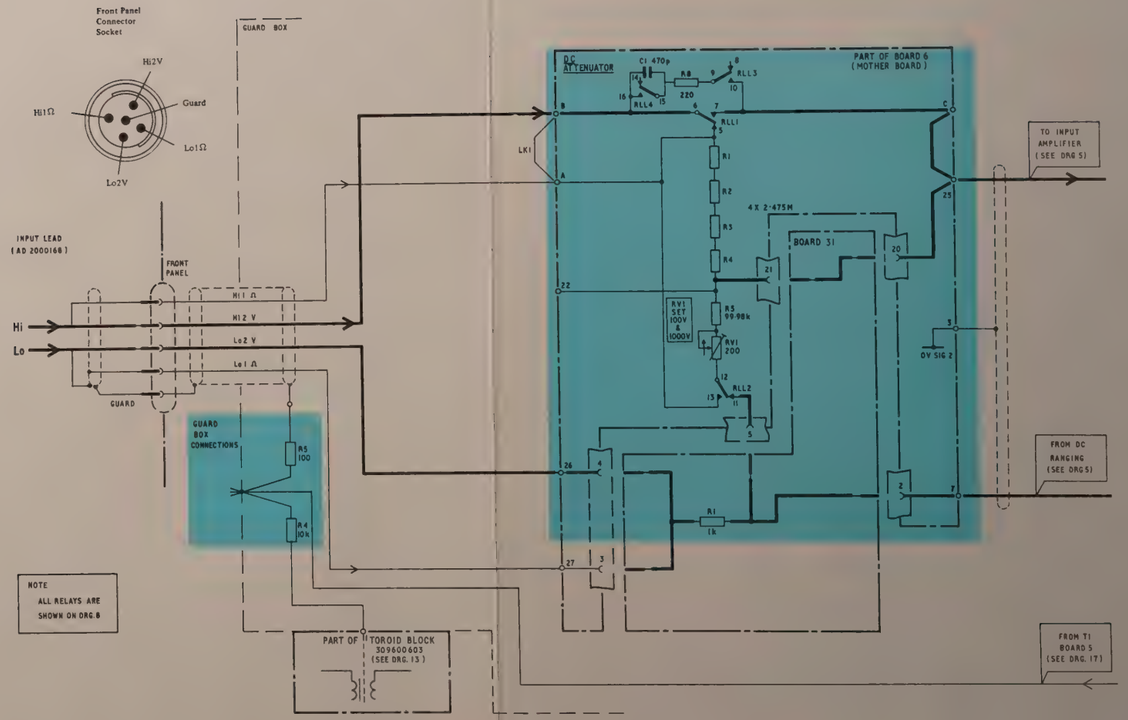


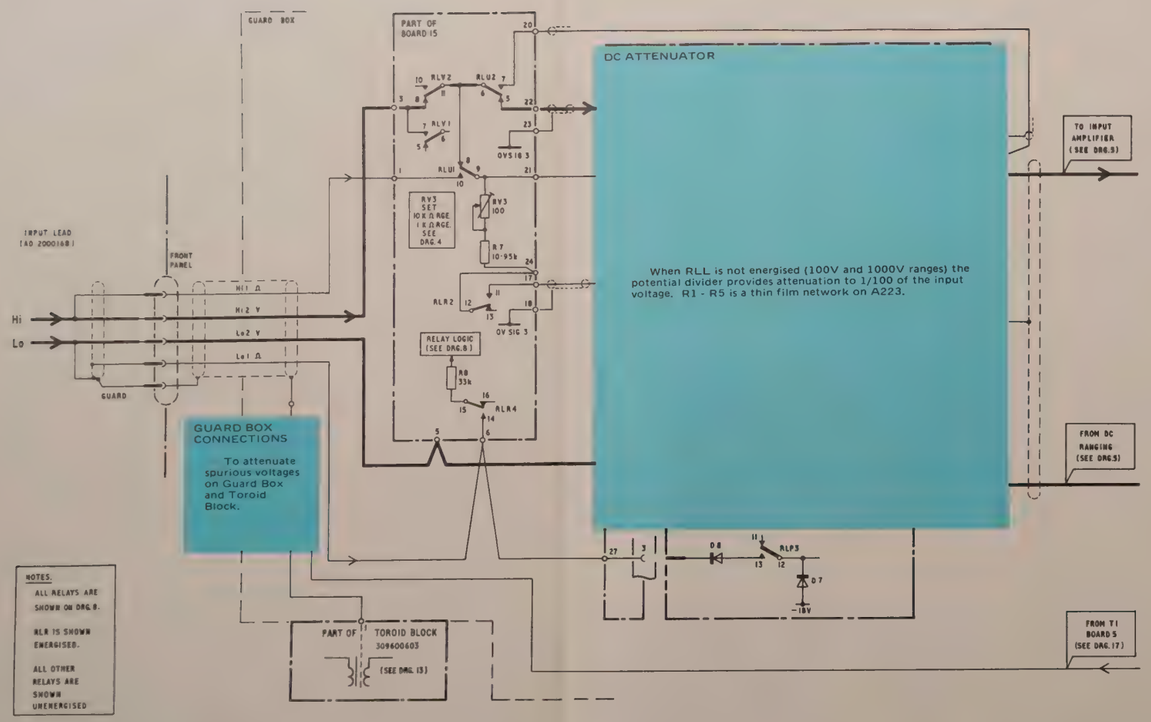
Fig.7.9 Pcb 6 (Copper Side)

PART OF FLOATING SECTION



DC INPUT CIRCUIT (WITHOUT AC,Ω) 1

PART OF FLOATING SECTION



Guard Box Connections

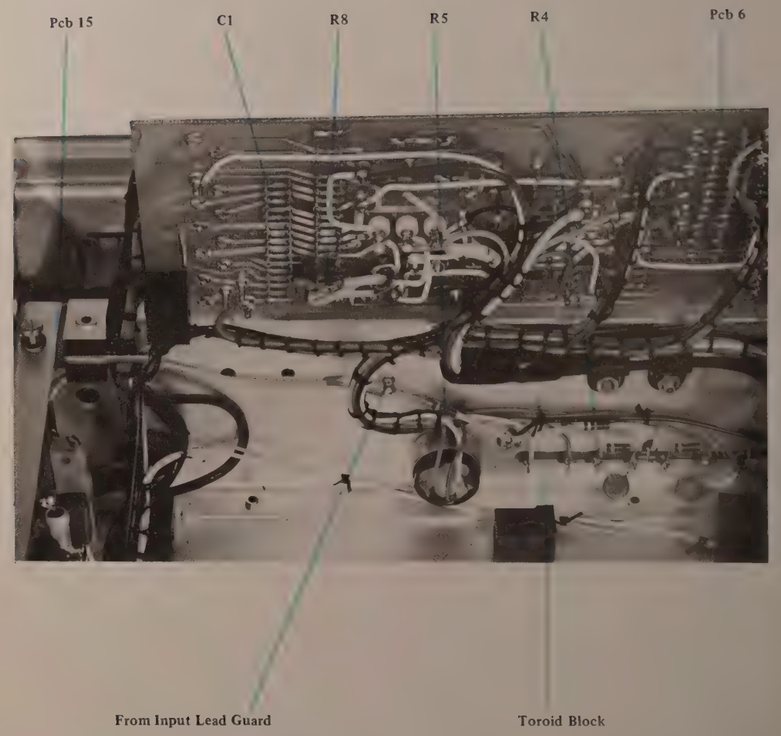


Fig. 7.11 Pcb 6. Copper Side Wiring

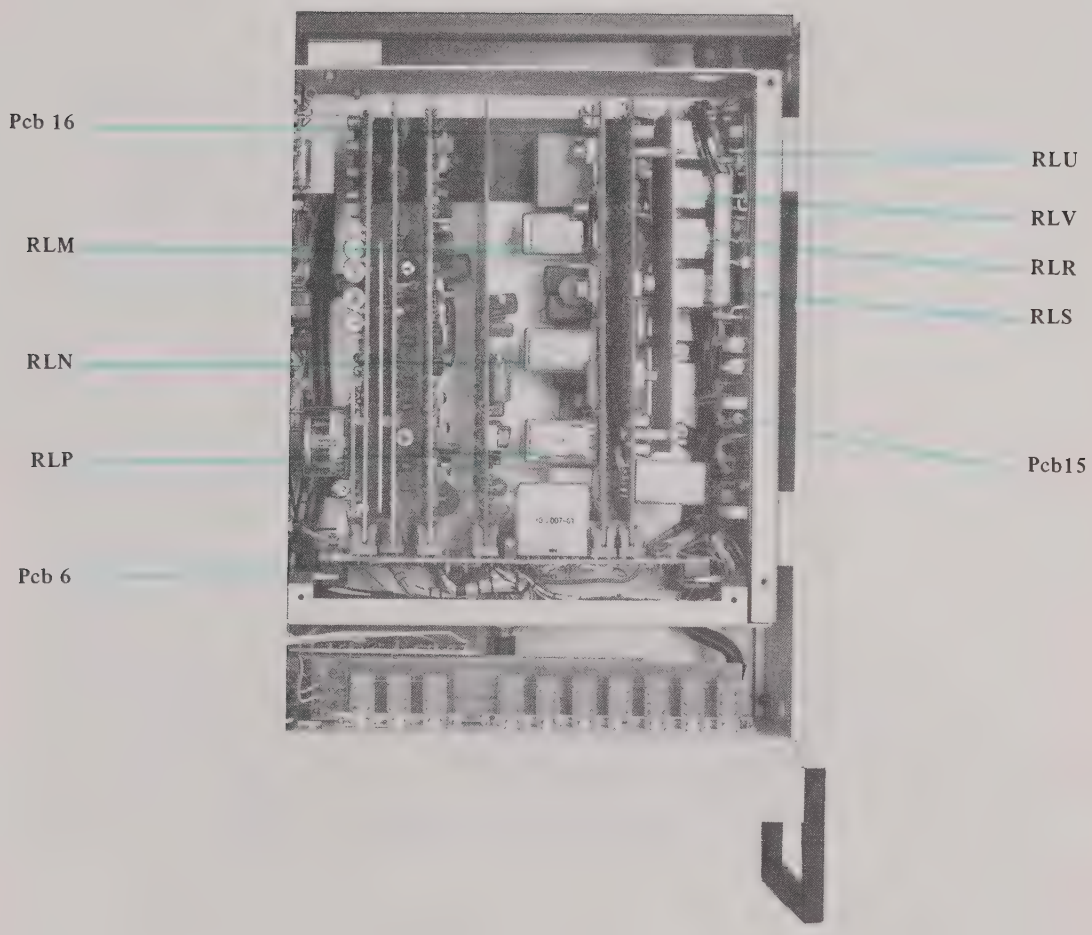


Fig 7.12 Pcb 6, Pcb 15 and Pcb 16

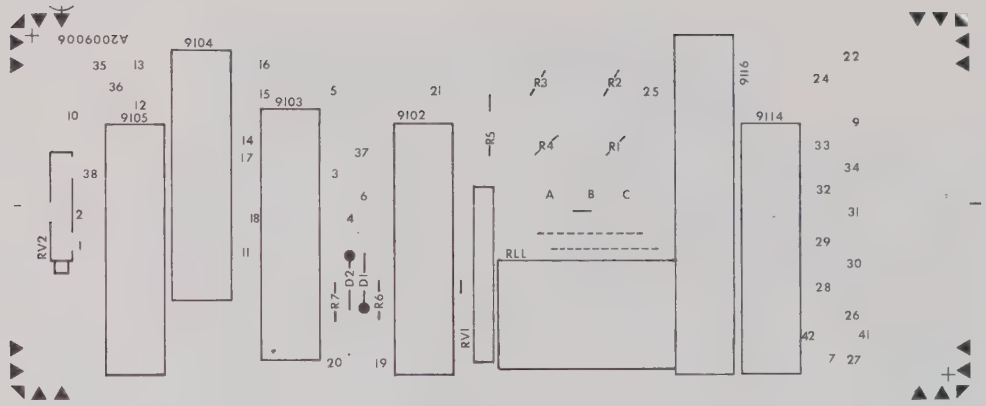


Fig. 7.13 Pcb 6 (Component Side)

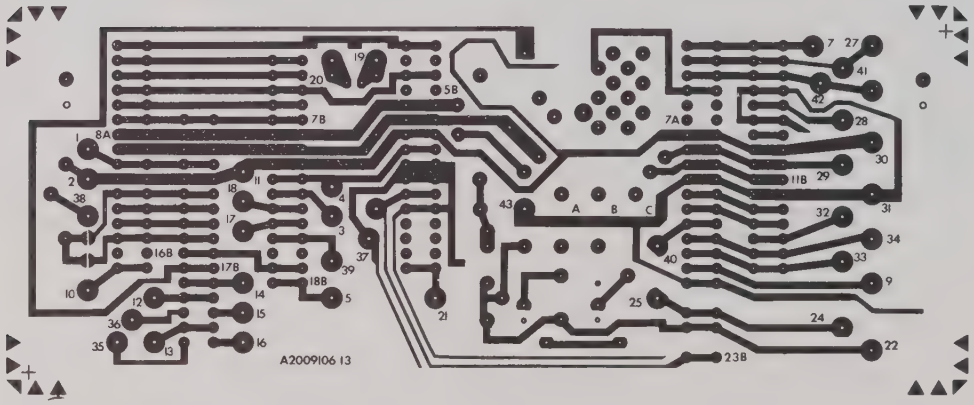
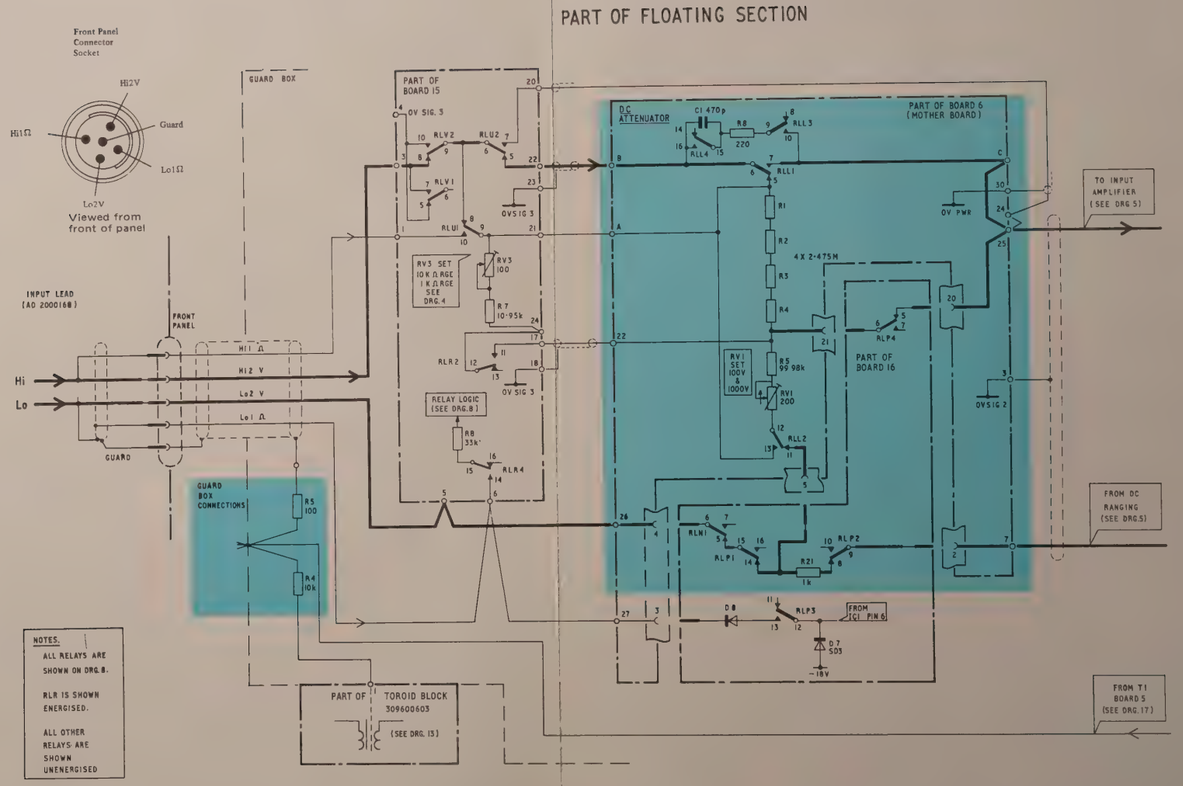
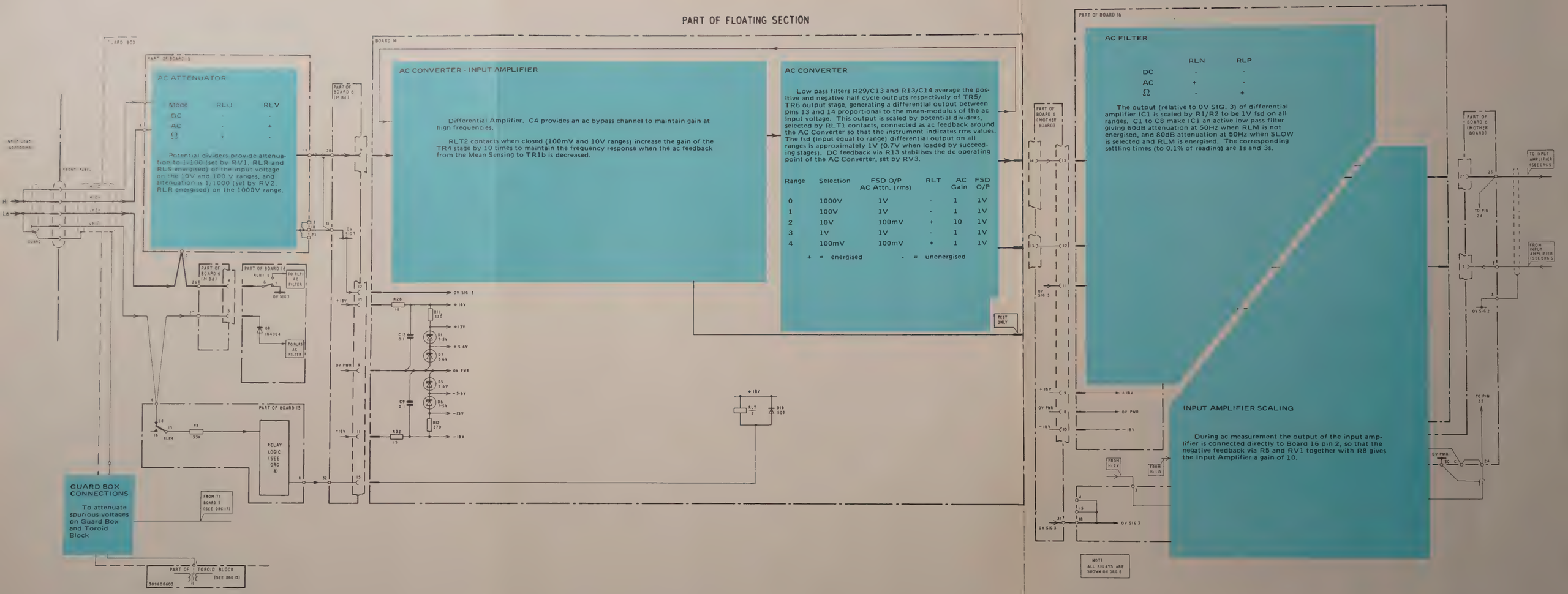


Fig. 7.14 Pcb 6 (Copper Side)

For Pcbs 15 and 16 Components see DRG 3 Figs.7.18 and 7.20.



DC INPUT CIRCUIT (WITH AC, Ω) 2


PART OF FLOATING SECTION
AC ATTENUATOR
Mode RLU RLV
DC - -
AC - +
Ω + -
Potential dividers provide attenuation to 1/100 (set by RV1, RLR and RLS energised) of the input voltage on the 10V and 100 V ranges, and attenuation is 1/1000 (set by RV2, RLR energised) on the 1000V range.
AC CONVERTER - INPUT AMPLIFIER
Differential Amplifier. C4 provides an ac bypass channel to maintain gain at high frequencies.
RLT2 contacts when closed (100mV and 10V ranges) increase the gain of the TR4 stage by 10 times to maintain the frequency response when the ac feedback from the Mean Sensing to TR1b is decreased.
AC CONVERTER
Low pass filters R29/C13 and R13/C14 average the positive and negative half cycle outputs respectively of TR5/TR6 output stage, generating a differential output between pins 13 and 14 proportional to the mean-modulus of the ac input voltage. This output is scaled by potential dividers, selected by RLT1 contacts, connected as ac feedback around the AC Converter so that the instrument indicates rms values. The fsd (input equal to range) differential output on all ranges is approximately 1V (0.7V when loaded by succeeding stages). DC feedback via R13 stabilises the dc operating point of the AC Converter, set by RV3.
Range Selection FSD O/P AC Attn. (rms) RLT AC Gain FSD O/P
0 1000V 1V - 1 1V
1 100V 1V - 1 1V
2 10V 100mV + 10 1V
3 1V 1V - 1 1V
4 100mV 100mV + 1 1V
+ = energised - = unenergised
TEST ONLY
GUARD BOX CONNECTIONS
To attenuate spurious voltages on Guard Box and Toroid Block
PART OF TOROID BLOCK (SEE DRG 13)
RELAY LOGIC (SEE DRG 8)
PART OF BOARD 16
AC FILTER
RLN RLP
DC - -
AC + -
Ω - +
The output (relative to 0V SIG. 3) of differential amplifier IC1 is scaled by R1/R2 to be 1V fsd on all ranges. C1 to C8 make IC1 an active low pass filter giving 60dB attenuation at 50Hz when RLM is not energised, and 80dB attenuation at 50Hz when SLOW is selected and RLM is energised. The corresponding settling times (to 0.1% of reading) are 1s and 3s.
INPUT AMPLIFIER SCALING
During ac measurement the output of the input amplifier is connected directly to Board 16 pin 2, so that the negative feedback via R5 and RV1 together with R8 gives the Input Amplifier a gain of 10.
NOTE ALL RELAYS ARE SHOWN ON DRG 8

AC INPUT (MEAN SENSING, A203 AND A223) DESCRIPTION

3

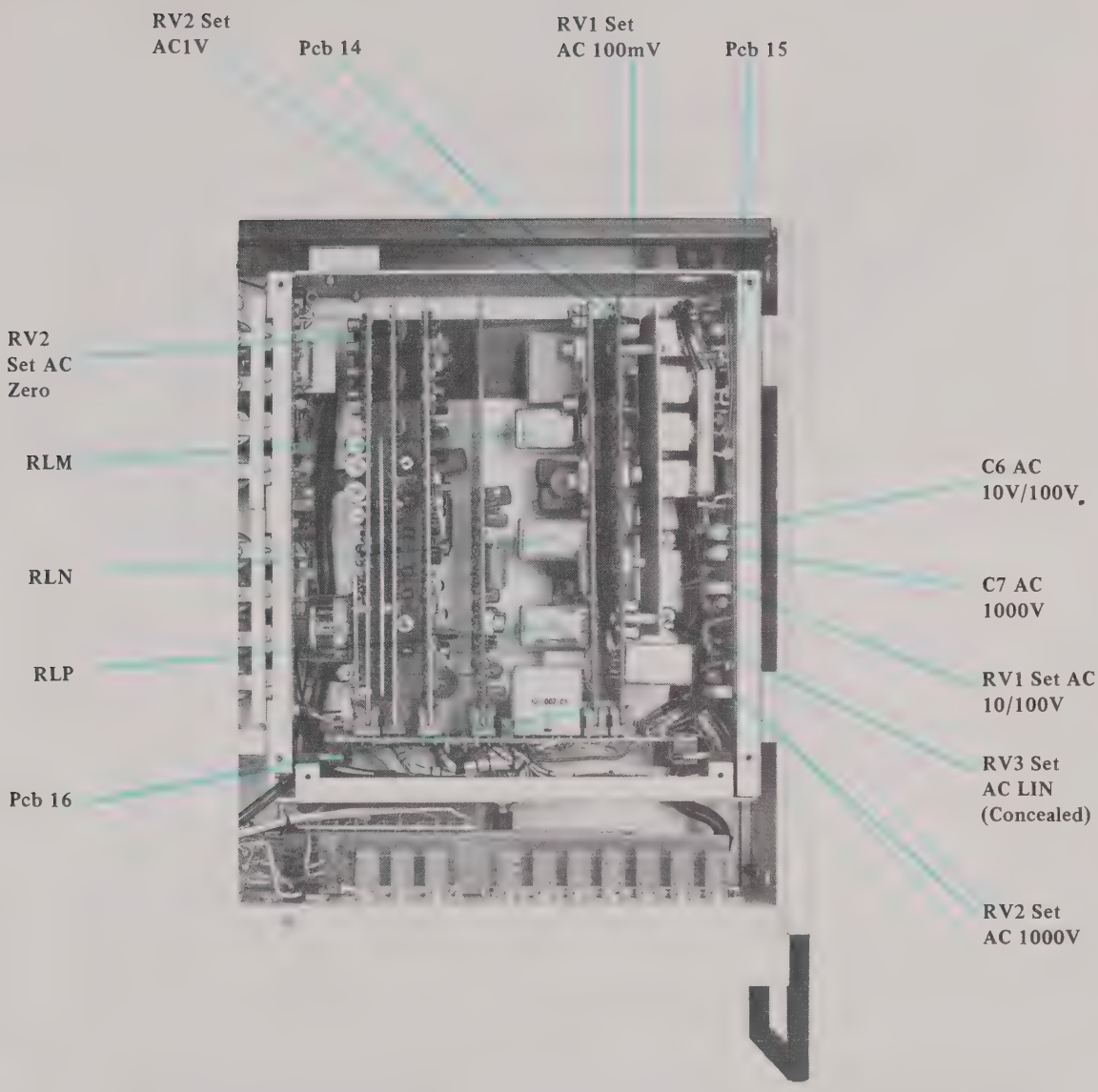


Fig. 7.15 Pcb's 14, 15 , 16 and 6

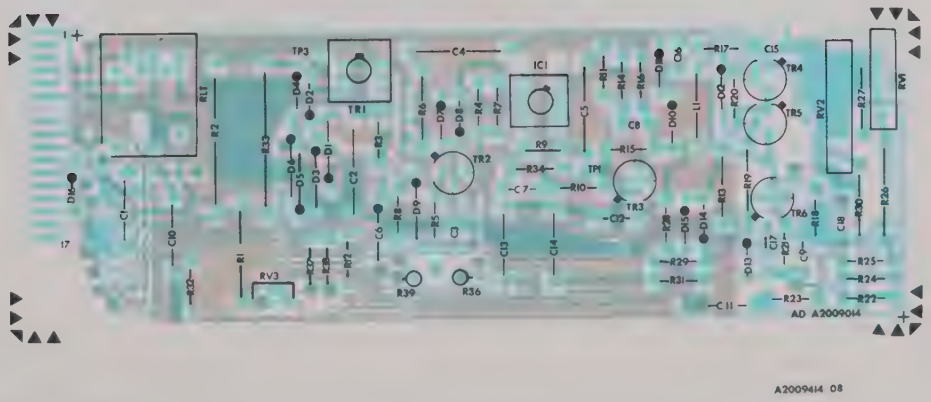


Fig. 7.16 Pcb 14

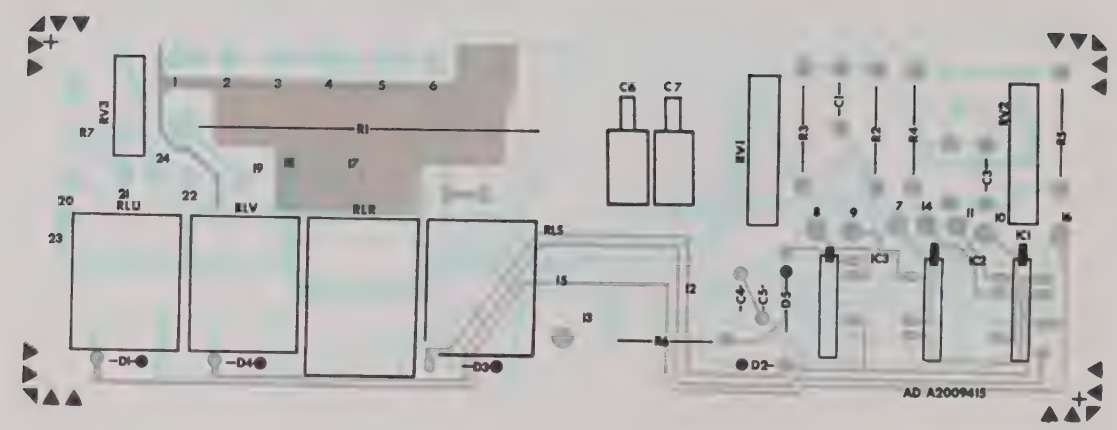


Fig. 7.18 Pcb 15

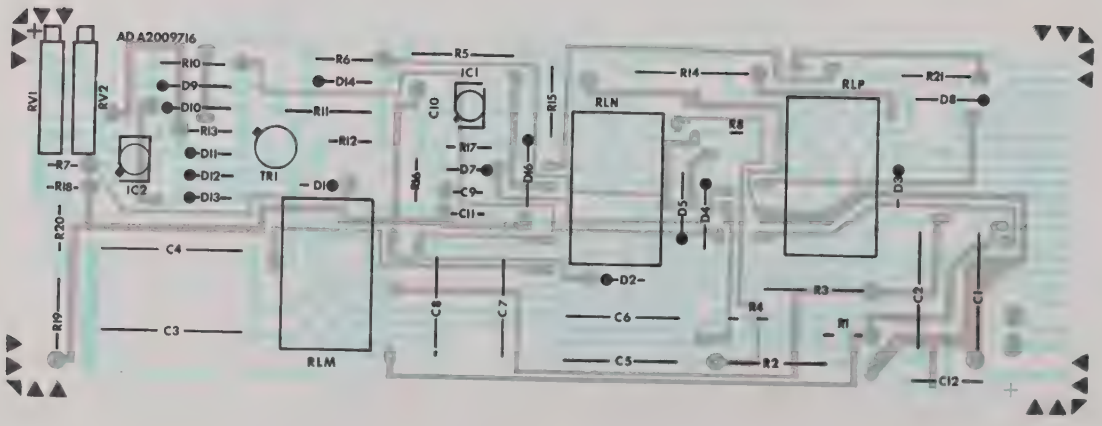


Fig. 7.20 Pcb 16

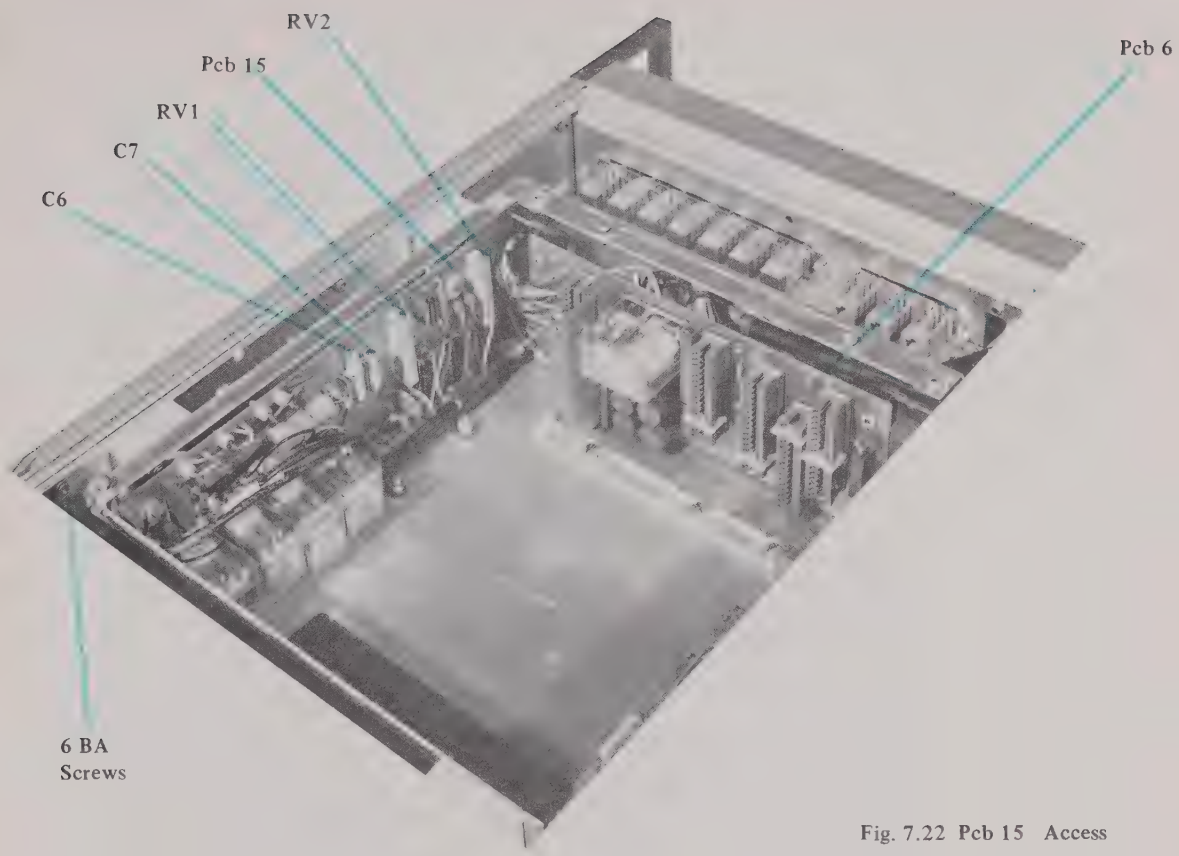


Fig. 7.22 Pcb 15 Access

For access to the copper side, remove the three 6 BA screws; two at the top and one bottom centre. Hi 1Ω (Red) Hi 2V (Yellow) Lo 2V (Green) Lo 1Ω (Blue) Guard (Black) from the Input Socket (Front Panel) are located on the copper side of Pcb 15.

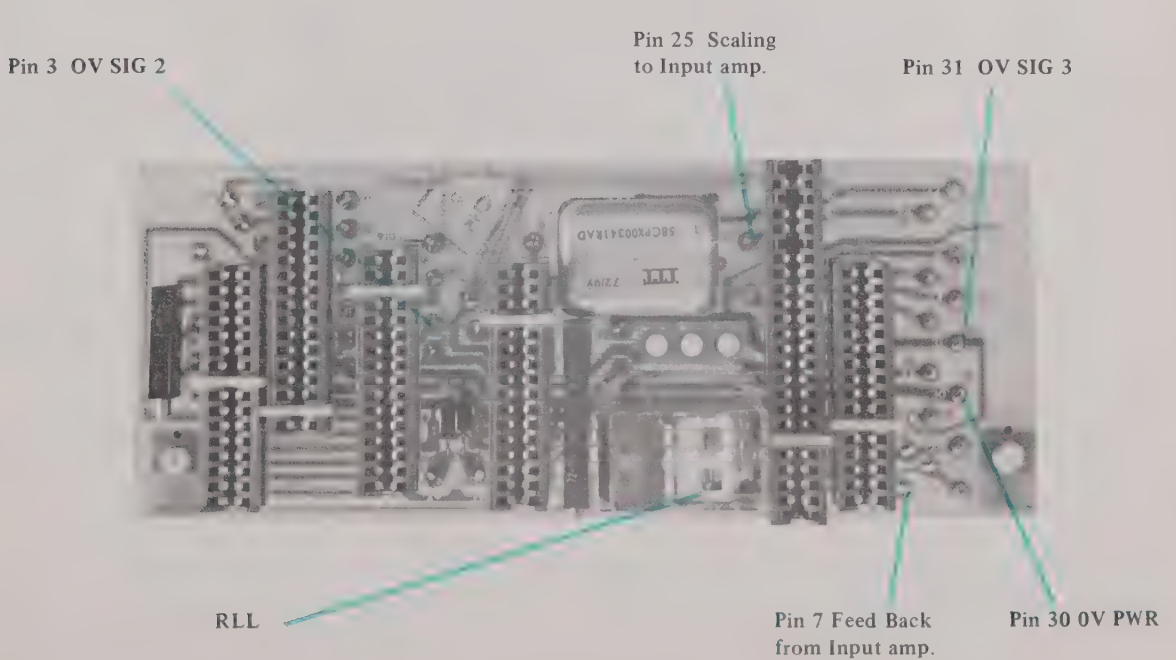
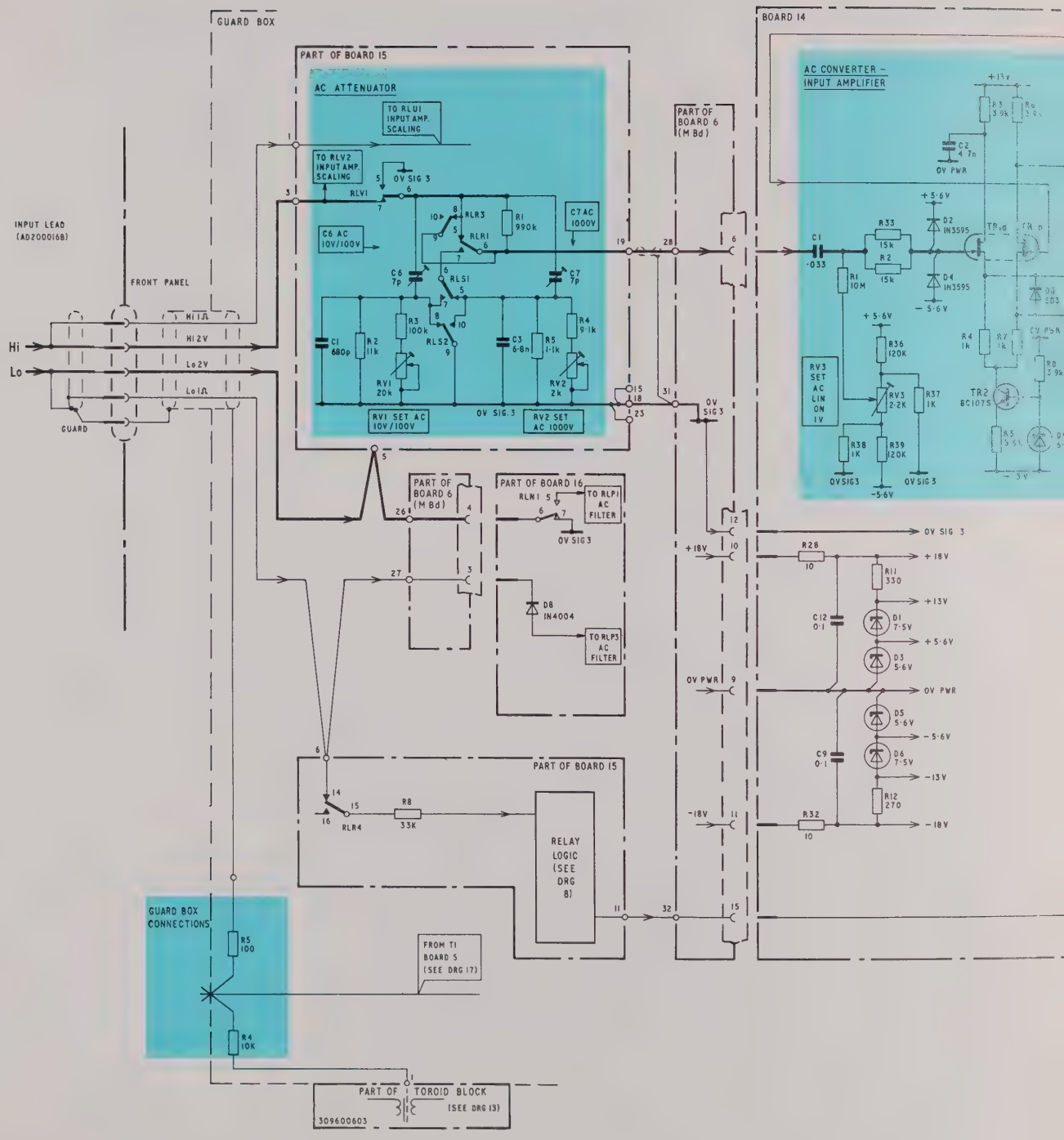
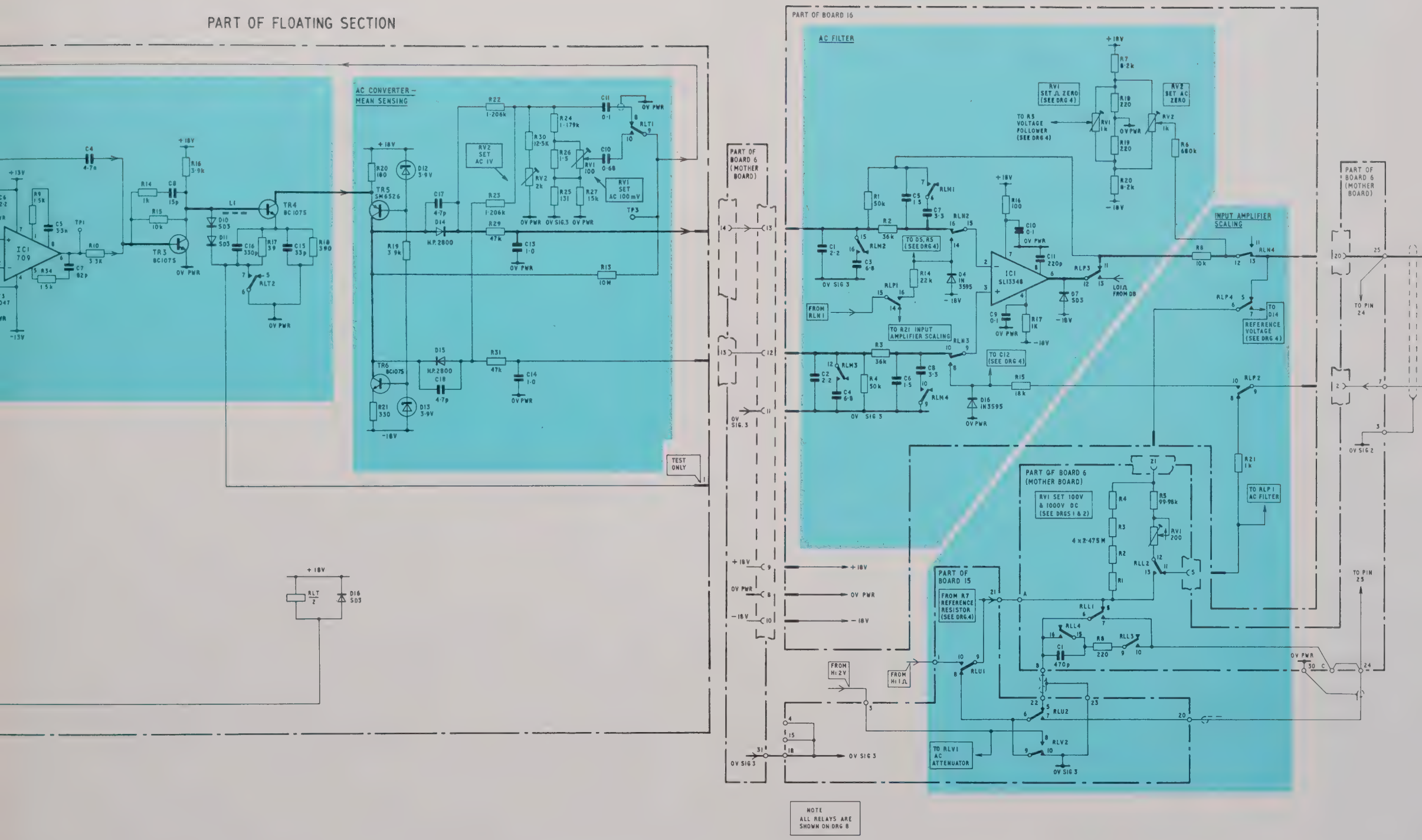
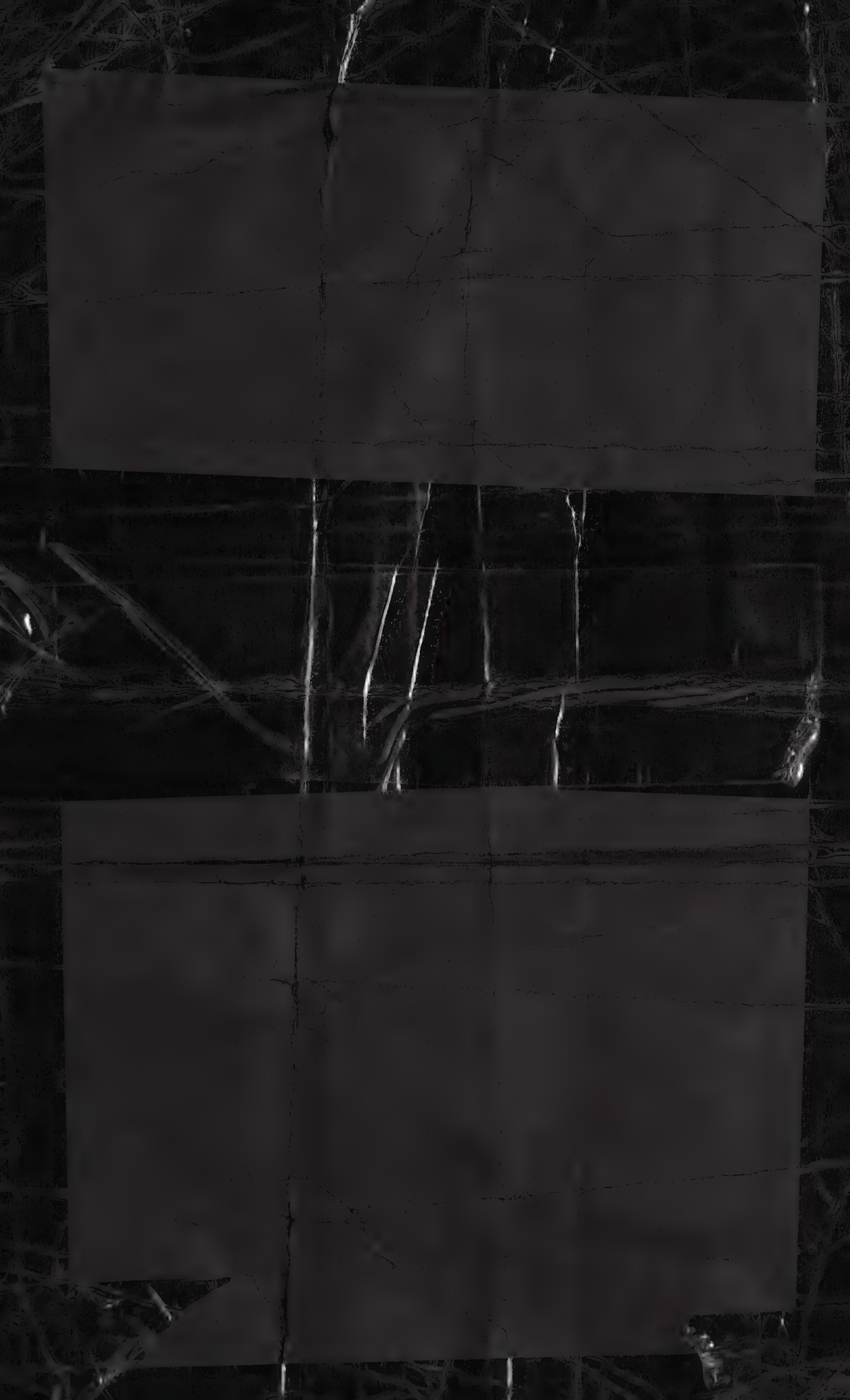


Fig. 7.23 Pcb 6 (A223)


GUARD BOX
PART OF BOARD 15
AC ATTENUATOR
TO RLU1 INPUT AMP. SCALING
TO RLV2 INPUT AMP. SCALING
0V SIG 3
RLV1
RLR3
RLR1
RLS1
RLS2
R1 990k
C7 AC 1000V
C6 AC 10V/100V
C6 7p
C7 7p
C1 680p
R2 11k
R3 100k
R4 9·1k
R5 1·1k
C3 6·8n
RV1 20k
RV2 2k
RV1 SET AC 10V/100V
RV2 SET AC 1000V
0V SIG.3
INPUT LEAD (AD200016B)
FRONT PANEL
Hi
Lo
HiIΩ
Hi2V
Lo2V
LoIΩ
GUARD
PART OF BOARD 6 (M Bd)
PART OF BOARD 16
RLN1
TO RLP1 AC FILTER
TO RLP3 AC FILTER
D8 IN4004
PART OF BOARD 15
RLR4
R8 33K
RELAY LOGIC (SEE DRG 8)
GUARD BOX CONNECTIONS
R5 100
R4 10K
FROM T1 BOARD 5 (SEE DRG 17)
PART OF TOROID BLOCK (SEE DRG 13)
309600603
BOARD 14
AC CONVERTER – INPUT AMPLIFIER
+13V
C2 4·7n
0V PWR
+5·6V
D2 IN3595
D4 IN3595
C1 ·033
R33 15k
R2 15k
R1 10M
-5·6V
R36 120K
RV3 SET AC LIN ON 1V
RV3 2·2K
R37 1K
R38 1K
R39 120K
TR2 BC107S
R4 1k
R7 1k
R8 3·9k
R5 1·5k
0V SIG3
+18V
R28 10
R11 330
C12 0·1
D1 7·5V
D3 5·6V
D5 5·6V
C9 0·1
D6 7·5V
-13V
R12 270
R32 10
-18V


PART OF FLOATING SECTION
AC CONVERTER – MEAN SENSING
AC FILTER
PART OF BOARD 16
PART OF BOARD 6 (MOTHER BOARD)
INPUT AMPLIFIER SCALING
PART OF BOARD 15
TEST ONLY
NOTE ALL RELAYS ARE SHOWN ON DRG 8
TO R5 VOLTAGE FOLLOWER (SEE DRG 4)
RV1 SET AC 1V
RV1 SET AC 100 mV
RV1 SET 100V & 1000V DC (SEE DRGS 1 & 2)
TO RLP1 AC FILTER
TO RLV1 AC ATTENUATOR
FROM R7 REFERENCE RESISTOR (SEE DRG 4)
TO D14 REFERENCE VOLTAGE (SEE DRG 4)
TO INPUT AMPLIFIER (SEE DRG 5)
FROM INPUT AMPLIFIER (SEE DRG 5)
TO PIN 24
TO PIN 25
OV SIG 3
OV PWR
+18V
-18V

AC INPUT (MEAN SENSING) CIRCUIT **3a**



DRG. 3b AC CONVERTER (TRUE RMS)

Drg. 3b of this supplement shows the complete circuit diagram for Board 41, the true rms ac converter, and it complements with Drg. 3a.

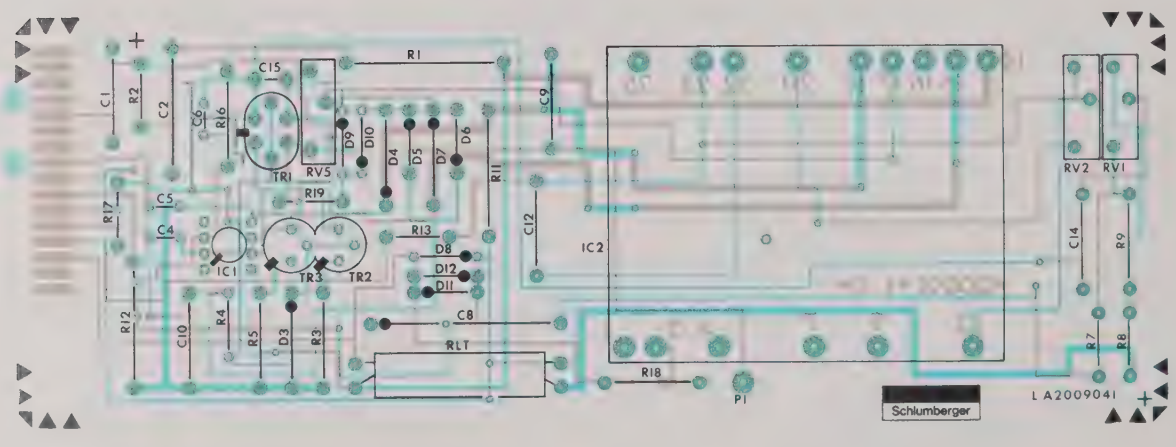
PRINTED CIRCUIT BOARD 41 (A2009041)

True RMS measurement is performed by boards 15 and 41, Board 15, the AC Auxiliary board is the same as that used in DVM Types A203 and A223. Board 41, True RMS Converter, contains the true rms computing encapsulated module and this board is directly substituted for board 14 (Mean Sensing Converter) in DVM Types A205 and A225.

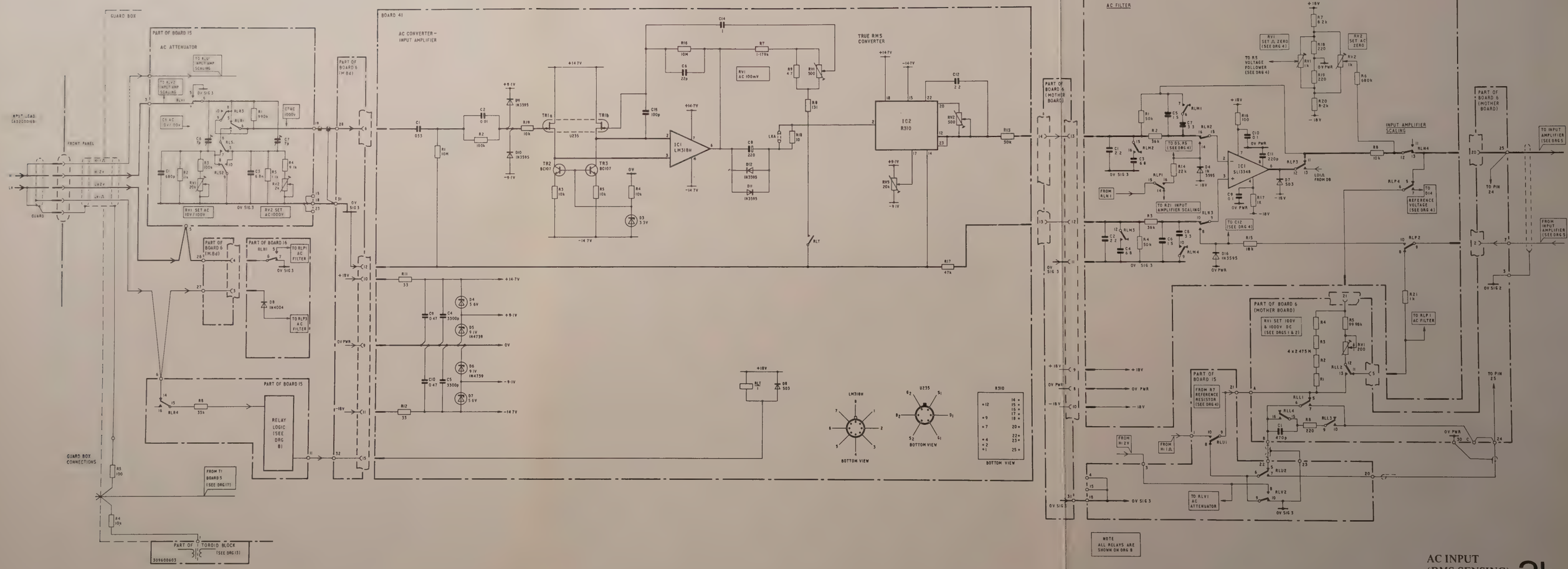
PCB LOCATIONS

DVM TYPES A205 AND A225

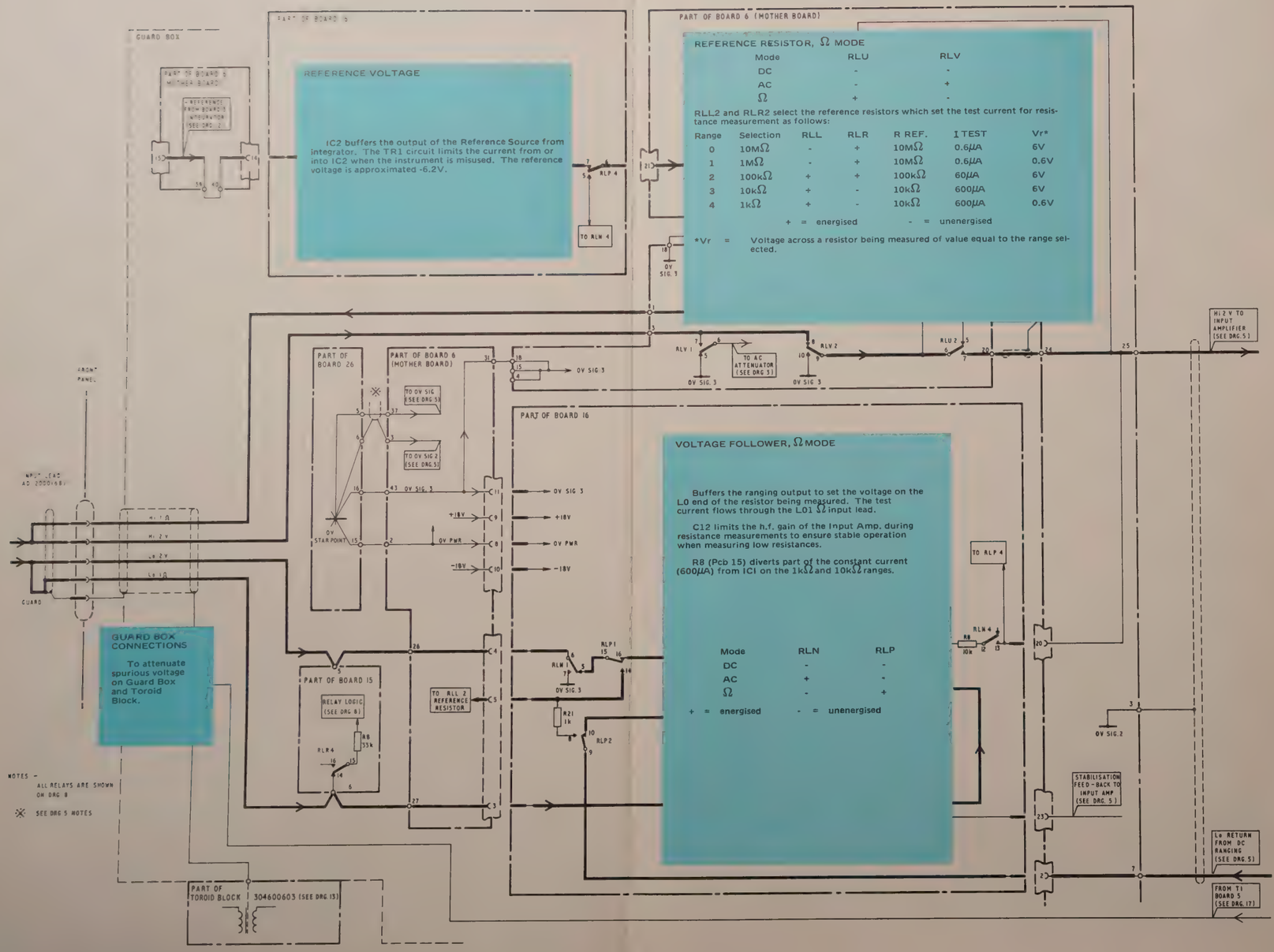
Refer to Fig. 7.15, Section 7.3.2, and substitute PCB 41 for PCB 14.



Component layout pcb No. 41


GUARD BOX
PART OF BOARD 15
AC ATTENUATOR
BOARD 41
AC CONVERTER – INPUT AMPLIFIER
TRUE RMS CONVERTER
PART OF BOARD 16
AC FILTER
PART OF BOARD 6 (MOTHER BOARD)
INPUT AMPLIFIER SCALING
RELAY LOGIC (SEE DRG 8)
FRONT PANEL
GUARD BOX CONNECTIONS
PART OF T1 TOROID BLOCK (SEE DRG 13)
FROM T1 BOARD 5 (SEE DRG 17)
TO RLP1 AC FILTER
TO RLV1 AC ATTENUATOR
TO INPUT AMPLIFIER (SEE DRG 5)
FROM INPUT AMPLIFIER (SEE DRG 5)
TO PIN 24
TO PIN 25
REFERENCE VOLTAGE (SEE DRG 4)
LOW FROM D8
RV1 SET AC ZERO
RV2 SET AC ZERO
RV1 SET 100V & 1000V DC (SEE DRGS 1 & 2)
RV1 SET FL ZERO (SEE DRG 4)
TO RS VOLTAGE FOLLOWER (SEE DRG 4)
TO R21 INPUT AMPLIFIER SCALING
TO C12 (SEE DRG 4)
FROM R7 REFERENCE RESISTOR (SEE DRG 4)
FROM H 2V
FROM H I Ω
IC1 LM318H
IC2 R310
IC1 SL13348
BOTTOM VIEW
NOTE ALL RELAYS ARE SHOWN ON DRG 8

AC INPUT (RMS SENSING) CIRCUIT 3b


GUARD BOX
PART OF BOARD 6 (MOTHER BOARD)
REFERENCE VOLTAGE
IC2 buffers the output of the Reference Source from integrator. The TR1 circuit limits the current from or into IC2 when the instrument is misused. The reference voltage is approximated -6.2V.
REFERENCE RESISTOR, Ω MODE
Mode RLU RLV
DC - -
AC - +
Ω + -
RLL2 and RLR2 select the reference resistors which set the test current for resistance measurement as follows:
Range Selection RLL RLR R REF. I TEST Vr*
0 10MΩ - + 10MΩ 0.6μA 6V
1 1MΩ - + 10MΩ 0.6μA 0.6V
2 100kΩ + + 100kΩ 60μA 6V
3 10kΩ + - 10kΩ 600μA 6V
4 1kΩ + - 10kΩ 600μA 0.6V
+ = energised - = unenergised
*Vr = Voltage across a resistor being measured of value equal to the range selected.
PART OF BOARD 16
VOLTAGE FOLLOWER, Ω MODE
Buffers the ranging output to set the voltage on the LO end of the resistor being measured. The test current flows through the LO1 Ω input lead.
C12 limits the h.f. gain of the Input Amp. during resistance measurements to ensure stable operation when measuring low resistances.
R8 (Pcb 15) diverts part of the constant current (600μA) from IC1 on the 1kΩ and 10kΩ ranges.
Mode RLN RLP
DC - -
AC + -
Ω - +
+ = energised - = unenergised
GUARD BOX CONNECTIONS
To attenuate spurious voltage on Guard Box and Toroid Block.
PART OF BOARD 26
PART OF BOARD 15
RELAY LOGIC (SEE DRG 8)
PART OF TOROID BLOCK 304600603 (SEE DRG 13)
TO RLL 2 REFERENCE RESISTOR
TO AC ATTENUATOR (SEE DRG 5)
TO RLP 4
STABILISATION FEED-BACK TO INPUT AMP (SEE DRG. 5)
Lo RETURN FROM DC RANGING (SEE DRG 5)
FROM T1 BOARD 5 (SEE DRG 17)
Hi 2 V TO INPUT AMPLIFIER (SEE DRG 5)
NOTES -
ALL RELAYS ARE SHOWN ON DRG 8
SEE DRG 5 NOTES

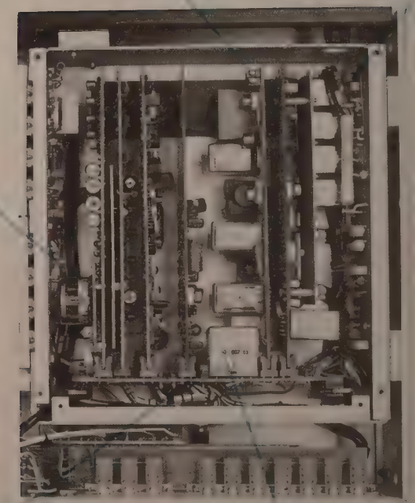


Fig. 7.24 Pcb's 26, 16, 15 and 6

Ω INPUT (A203 AND A223) DESCRIPTION 4

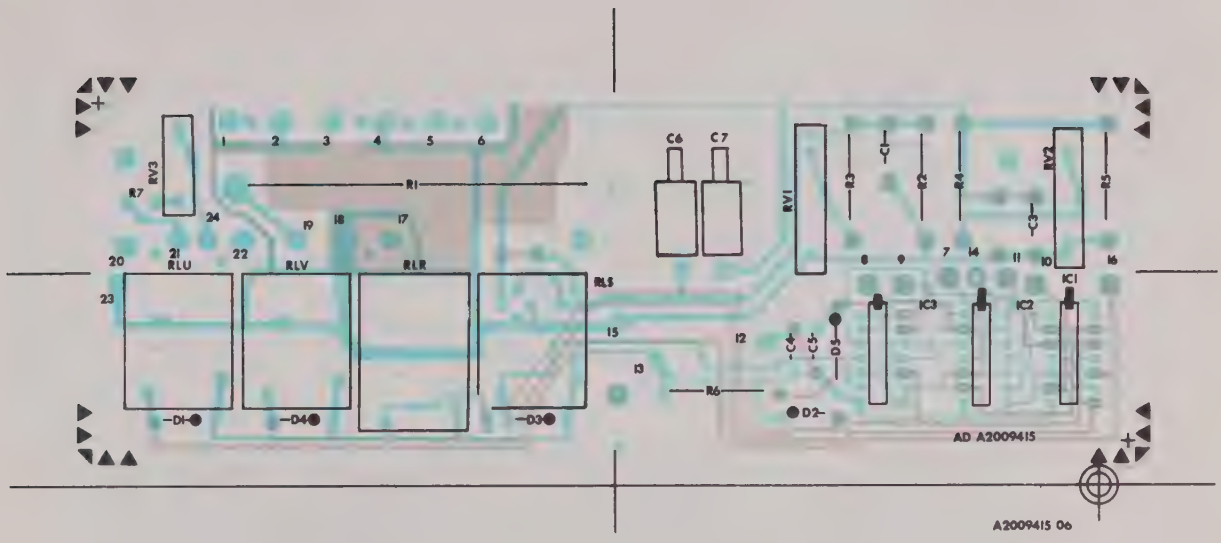


Fig. 7.25 Pcb 15

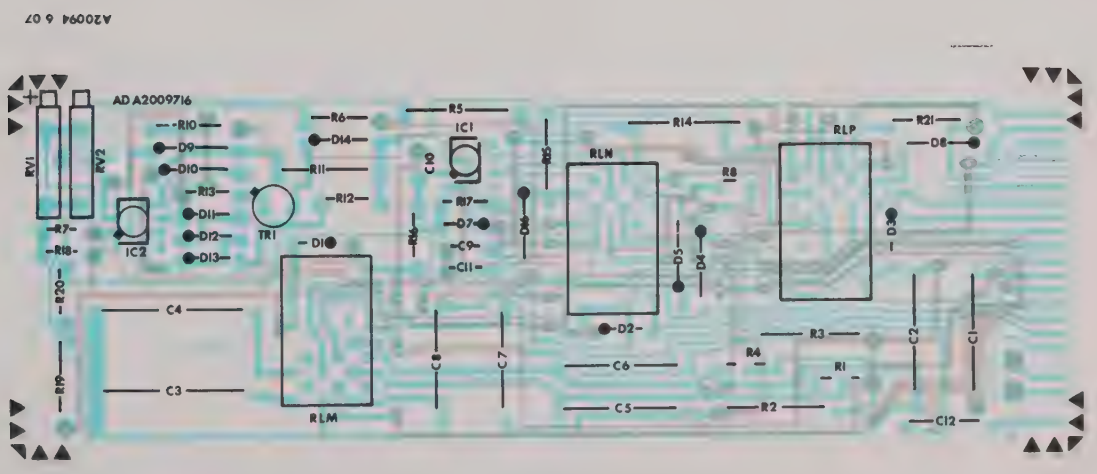


Fig. 7.27 Pcb 16

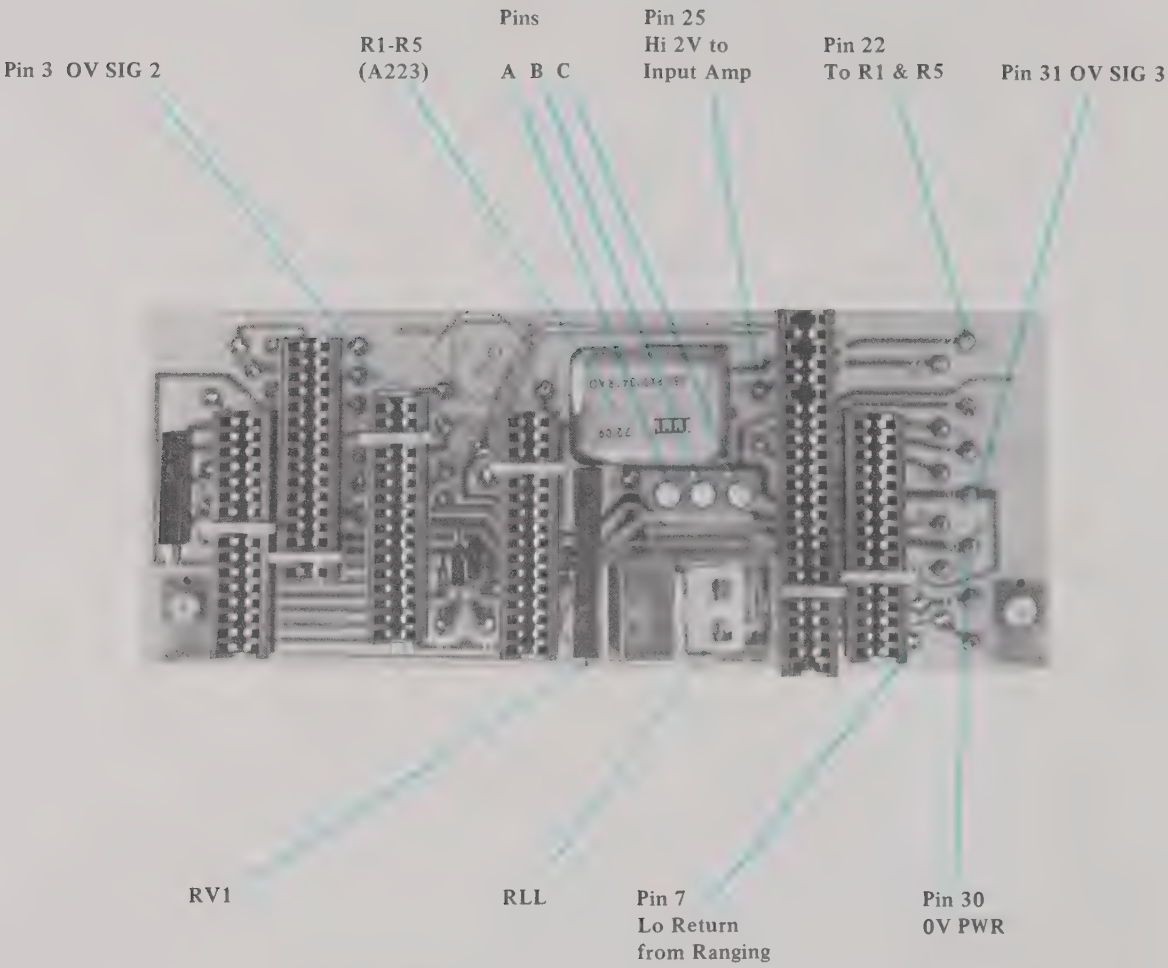
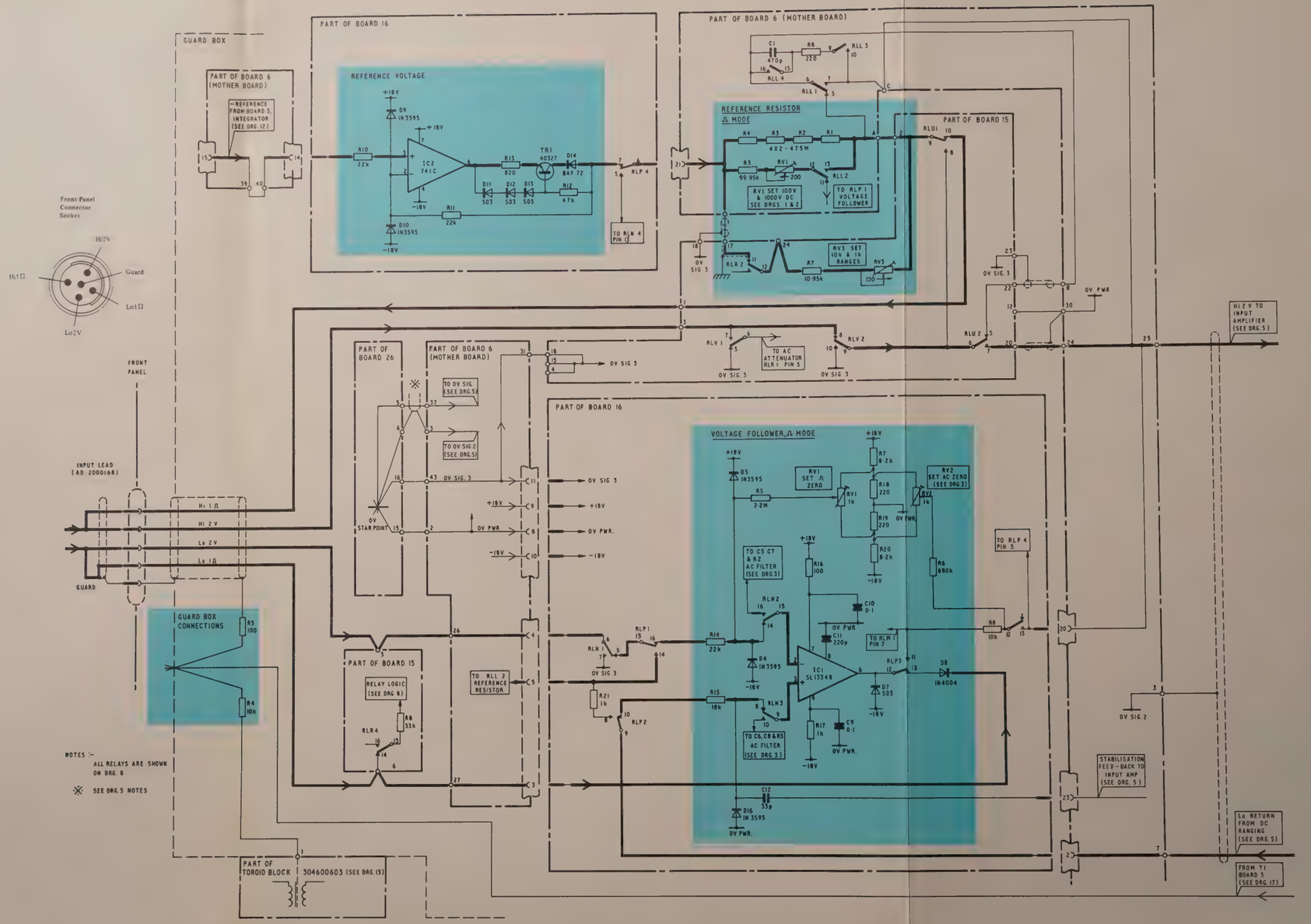


Fig. 7.29 Pcb 6 (Component Side)


GUARD BOX
PART OF BOARD 16
REFERENCE VOLTAGE
PART OF BOARD 6 (MOTHER BOARD)
REFERENCE FROM BOARD 3, INTEGRATOR (SEE DRG 12)
PART OF BOARD 6 (MOTHER BOARD)
REFERENCE RESISTOR Ω MODE
4X2 · 475M
RV1 SET 100V & 1000V DC SEE DRGS 1 & 2
TO RLP 1 VOLTAGE FOLLOWER
RV3 SET 10V & 1K RANGES
PART OF BOARD 15
TO RLN 4 PIN 13
Front Panel Connector Socket
Hi2V
Guard
Hi1Ω
Lo1Ω
Lo2V
FRONT PANEL
INPUT LEAD (AD 200/168)
Hi 1Ω
Hi 2 V
Lo 2 V
Lo 1Ω
GUARD
GUARD BOX CONNECTIONS
R5 100
R4 10k
NOTES :-
ALL RELAYS ARE SHOWN ON DRG. 8
※ SEE DRG.5 NOTES
PART OF BOARD 26
PART OF BOARD 6 (MOTHER BOARD)
TO 0V SIG 4 (SEE DRG.5X)
TO 0V SIG 2 (SEE DRG.5)
0V STAR POINT
0V SIG. 3
0V PWR
+18V
-18V
PART OF BOARD 15
RELAY LOGIC (SEE DRG 8)
TO RLL 2 REFERENCE RESISTOR
PART OF BOARD 16
VOLTAGE FOLLOWER Ω MODE
RV1 SET Ω ZERO
RV2 SET AC ZERO (SEE DRG 5)
TO CS C7 & R2 AC FILTER (SEE DRG 3)
TO CG, CB & R3 AC FILTER (SEE DRG 3)
TO RLW 1 PIN 7
TO RLP 4 PIN 5
IC1 SL13348
D8 IN4004
STABILISATION FEED-BACK TO INPUT AMP (SEE DRG. 5)
Lo RETURN FROM DC RANGING (SEE DRG. 5)
FROM T1 BOARD 5 (SEE DRG. 17)
Hi 2 V TO INPUT AMPLIFIER (SEE DRG. 5)
TO AC ATTENUATOR RLR 1 PIN 5
PART OF TOROID BLOCK 304600603 (SEE DRG. 13)

Ω INPUT CIRCUIT 4

PART OF FLOATING SECTION

PART OF BOARD 26

BOARD 2 (A200 OR A220)

INPUT AMP.

PART OF BOARD 6 (MOTHER BOARD)

PART OF BOARD 3

DC, AC/Ω SCALING

DC AND AC:

Links are cut on test and RV5 adjusted to set the 'gain' of the Integrator (see Drg. 12) and thus calibrate the instrument on the 10V (basic) range.

Ω:

During Ω measurements, RLF1 contacts are closed, and the 'gain' of the Integrator is set by RV4.

DC AND Ω FILTER

When SLOW is selected during DC and Ω measurements RLA is energised C1 to C4, selected by RLB, RLD and RLE in conjunction with R1, R2 and R3 in Overload Protection make the Input Amplifier behave as a low pass filter, giving the DVM an additional 30dB series mode rejection at 50Hz, increasing at 6dB/Octave. R4 is a current limiter protecting RLE when energised.

DC RANGING

RLB and RLD select potential dividers appropriate to the range selected.

During ac measurements the Input Amplifier output is always connected directly to Input Amplifier Scaling, shown on Drg. 3.

Range	Selection	RLD DC	RLD AC	RLD Ω	RLB DC	RLB AC	RLB Ω	Divisor DC	Divisor AC	Divisor Ω
0	1000V (10MΩ)	+	+	+	+	+	+	1	1	1
1	100V (1MΩ)	-	+	-	+	+	+	10	1	10
2	10V (100kΩ)	+	+	+	+	+	+	1	1	1
3	1V (10kΩ)	-	+	+	+	+	+	10	1	1
4	100mV (1kΩ)	+	+	-	-	+	+	100	1	10
5	(10mV)	-			-			1000		

\+ = energised - = unenergised

FILTER COMPENSATION

Injects a small pulse, amplitude set by RV2 and polarity set in test by the links, on to the Lo line to compensate for errors introduced by the Ramp Up Switch (see Drg. 12) at the start of ramp up.

SCALED AMPLIFIER OUTPUT TO INTEGRATOR (SEE DRG. 12)

PART OF TOROID BLOCK 309600603 (SEE DRG. 13)

PART OF BD 14 (SEE DRG. 3)

PART OF BD 15 (SEE DRGS 3 & 4)

PART OF BD 16 (SEE DRGS 3 & 4)

TO GUARD BOX CONNECTIONS (SEE DRGS. 1 TO 4)

GUARD BOX

NOTES:-
CONNECTIONS MARKED ※ ARE CONTAINED IN A COMMON SCREEN

ALL RELAYS ARE SHOWN ON DRG. 8

Pcb 26

Reed Relay Coils

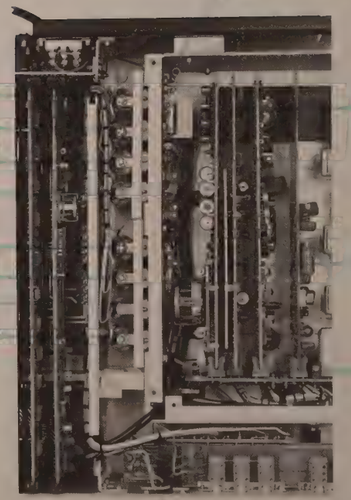


Fig. 7.30 Pcb 26 and Reed Relay Coils

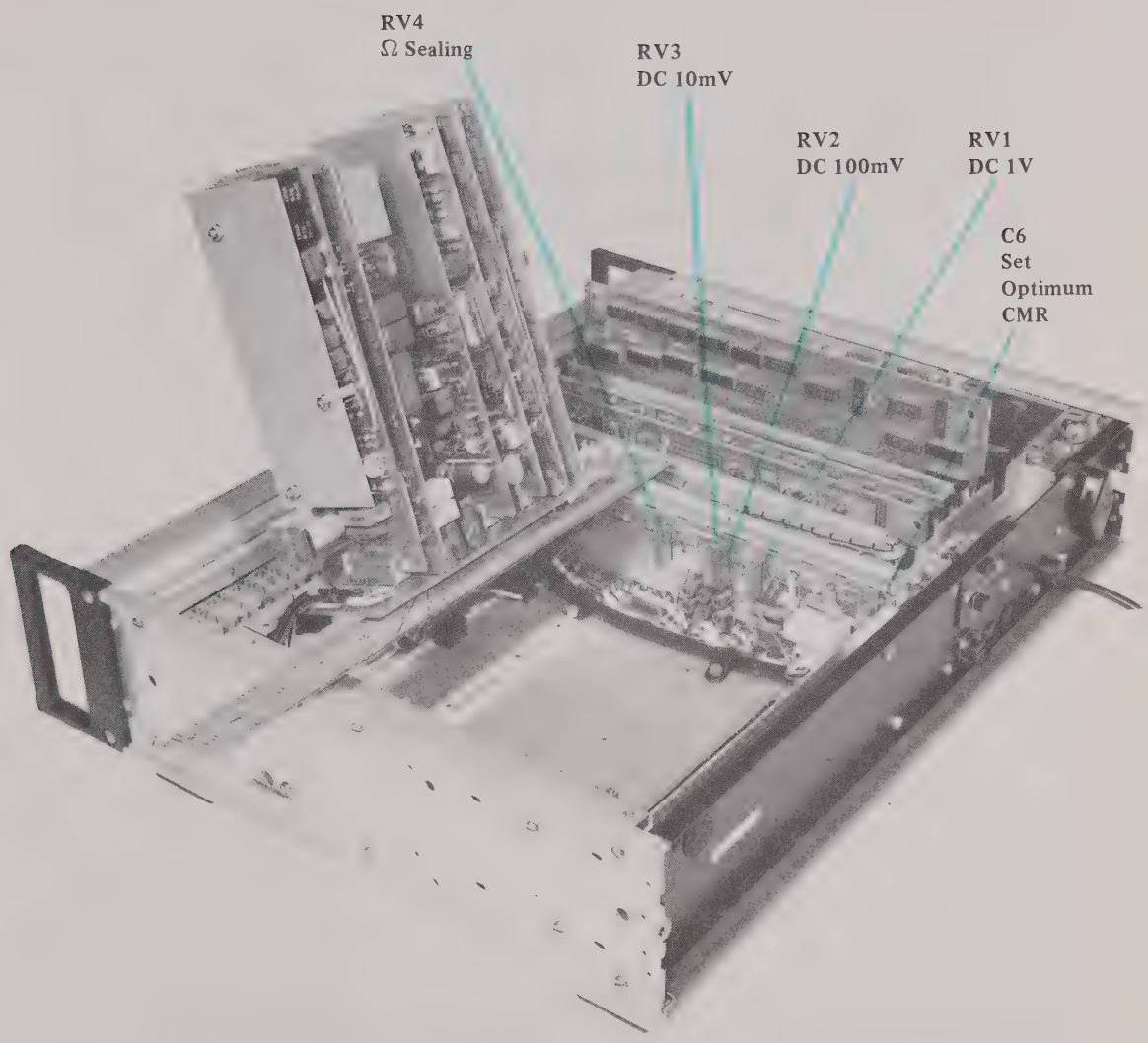


Fig. 7.31 Access to Pcb 26

With the Floating Section Cover removed, Pcb 6 with Pcb's 5,4,3,2, 16 (or.31) and 14 may be pivoted clear of the instrument and supported as shown.

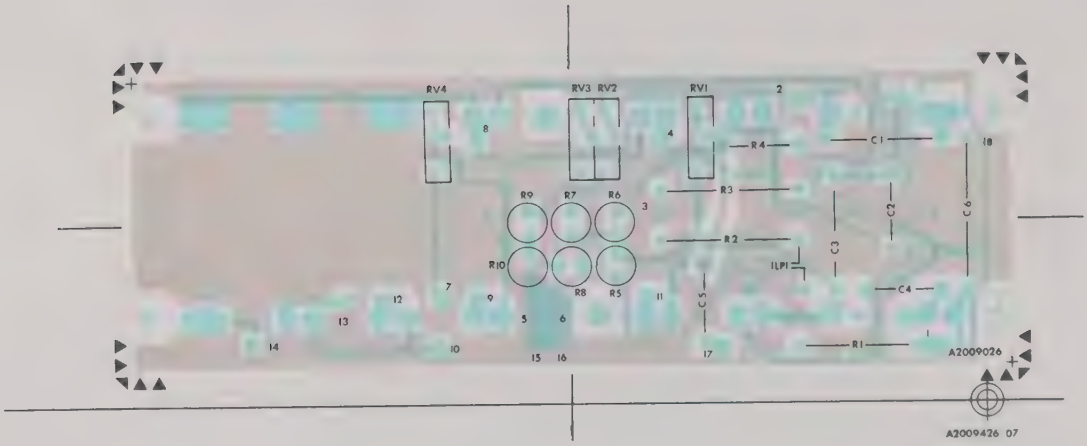


Fig. 7.32 Pcb 26

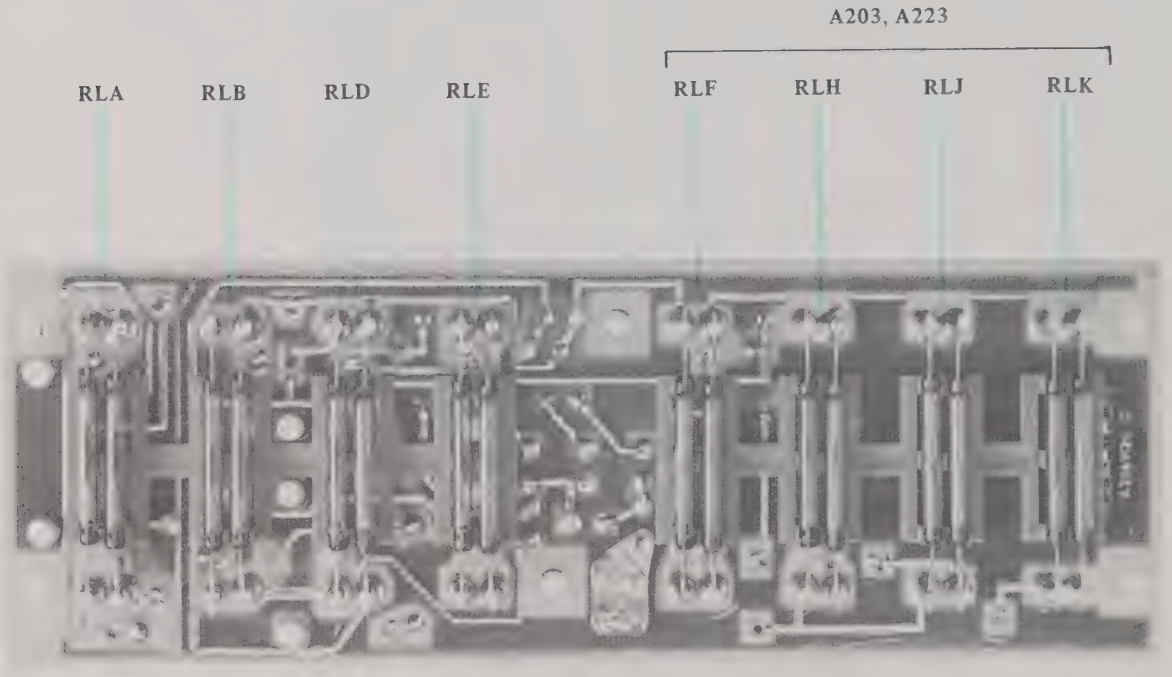


Fig. 7.34 Pcb 26. Copper Side and Reed Relay Contacts

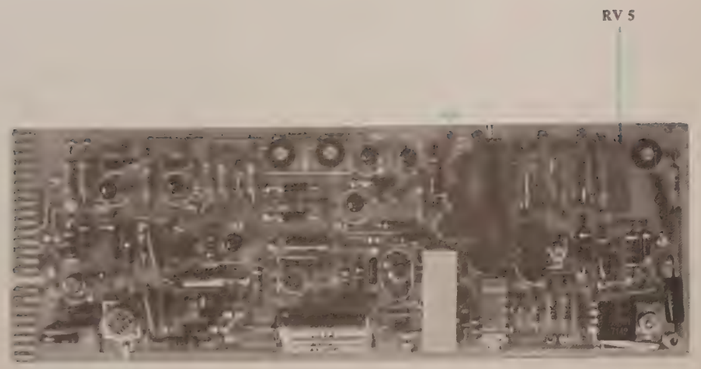
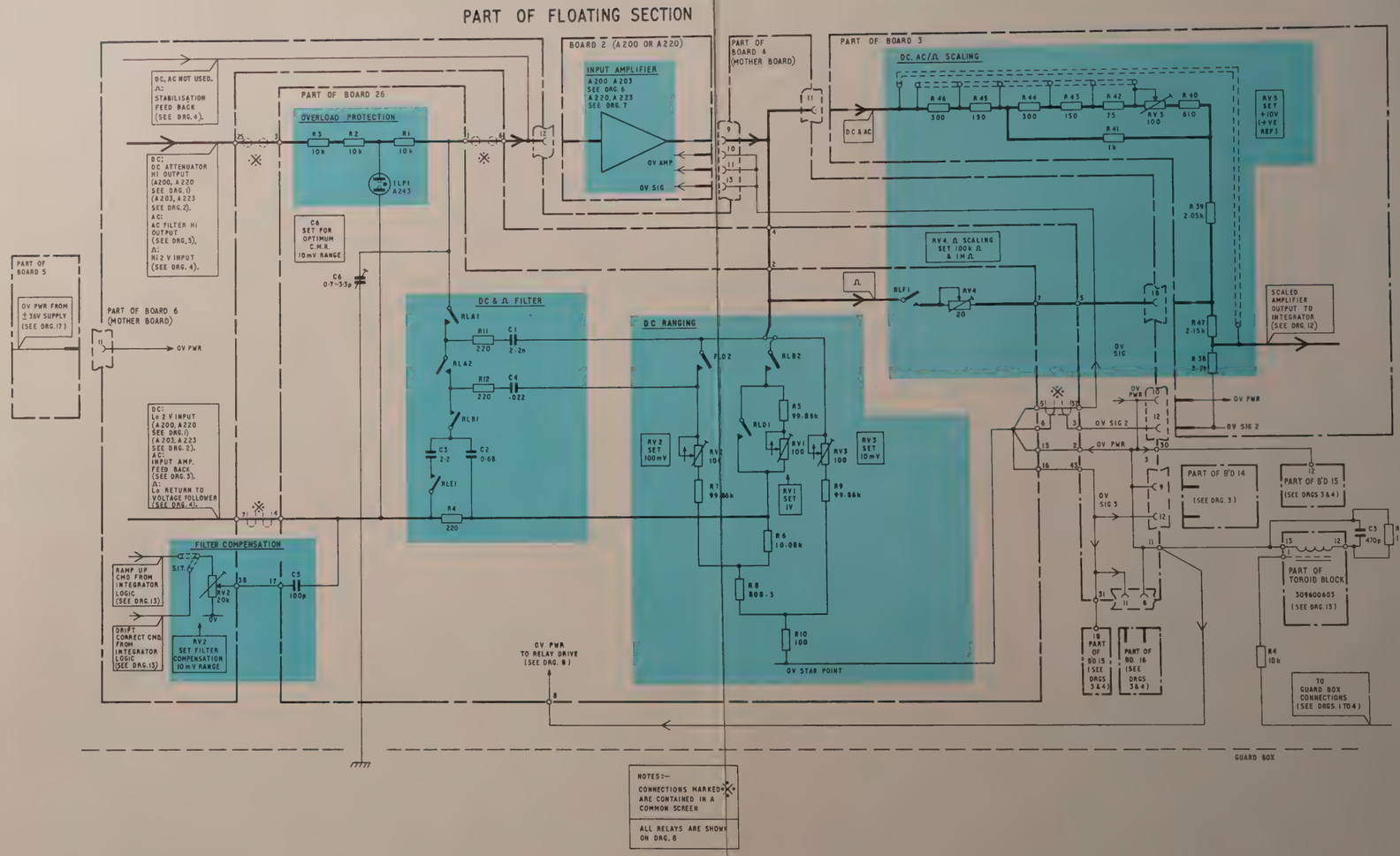


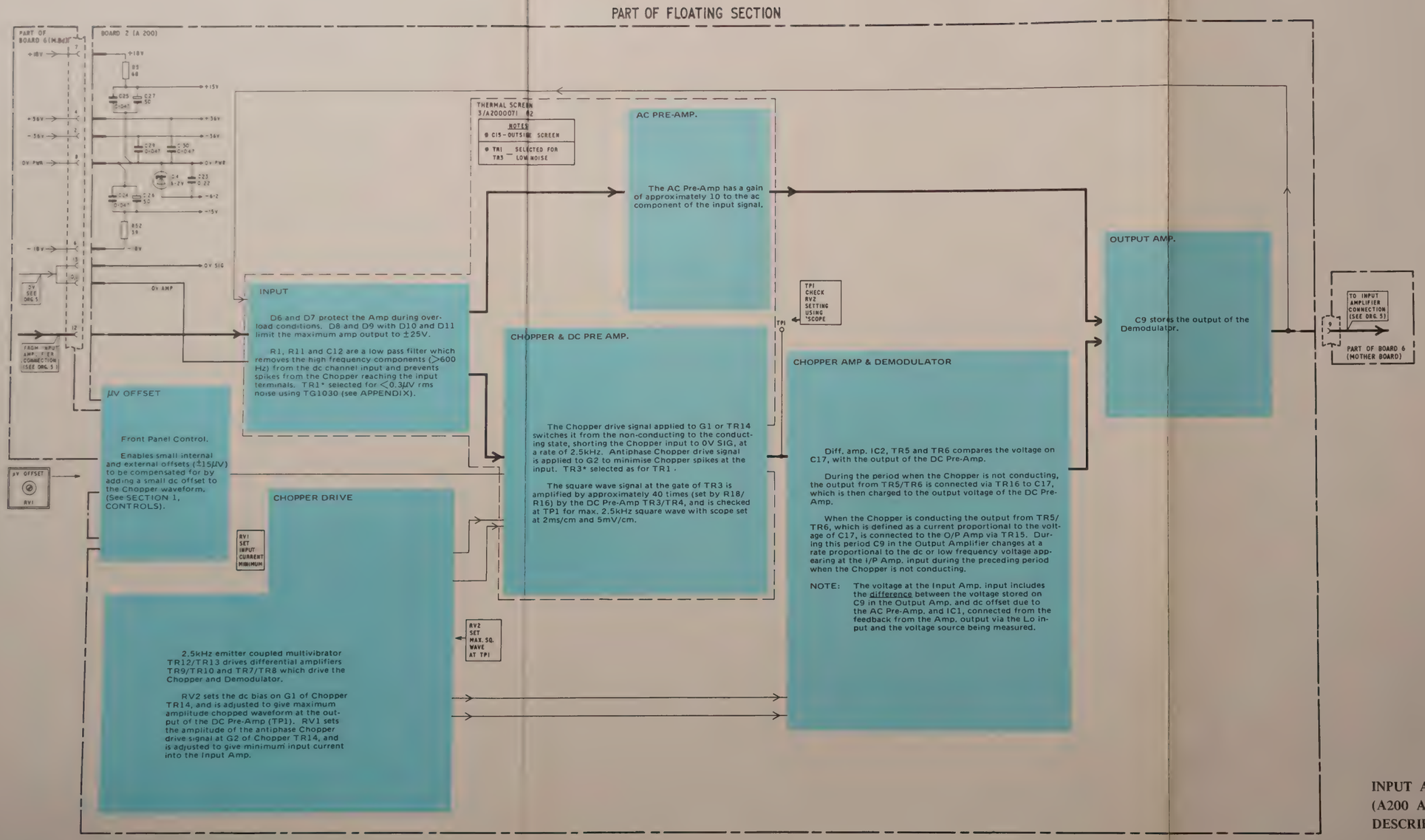
Fig. 7.35 Pcb 3

+ Scaled Amplifier Output to INTEGRATOR (see DRG 12) is 6.4V for a "19999" DVM Input, and is -VE for a +VE Input.



INPUT AMPLIFIER CONNECTION CIRCUIT

5


PART OF FLOATING SECTION
PART OF BOARD 6 (MOTHER BOARD)
BOARD 2 (A 200)
+18V
+15V
+36V
-36V
0V PWR
-8V2
-15V
-18V
-8V
0V SIG
0V AMP
2V SEE ORG 5
FROM INPUT AMPLIFIER CONNECTION (SEE ORG 5)
THERMAL SCREEN 3/A200007/ 02
NOTES
① C15 - OUTSIDE SCREEN
② TR1 — SELECTED FOR TR3 — LOW NOISE
AC PRE-AMP.
The AC Pre-Amp has a gain of approximately 10 to the ac component of the input signal.
INPUT
D6 and D7 protect the Amp during overload conditions. D8 and D9 with D10 and D11 limit the maximum amp output to ±25V.
R1, R11 and C12 are a low pass filter which removes the high frequency components (>600 Hz) from the dc channel input and prevents spikes from the Chopper reaching the input terminals. TR1* selected for <0.3μV rms noise using TG1030 (see APPENDIX).
TP1 CHECK RV2 SETTING USING 'SCOPE
TP1
CHOPPER & DC PRE AMP.
The Chopper drive signal applied to G1 or TR14 switches it from the non-conducting to the conducting state, shorting the Chopper input to 0V SIG, at a rate of 2.5kHz. Antiphase Chopper drive signal is applied to G2 to minimise Chopper spikes at the input. TR3* selected as for TR1.
The square wave signal at the gate of TR3 is amplified by approximately 40 times (set by R18/R16) by the DC Pre-Amp TR3/TR4, and is checked at TP1 for max. 2.5kHz square wave with scope set at 2ms/cm and 5mV/cm.
CHOPPER AMP & DEMODULATOR
Diff. amp. IC2, TR5 and TR6 compares the voltage on C17, with the output of the DC Pre-Amp.
During the period when the Chopper is not conducting, the output from TR5/TR6 is connected via TR16 to C17, which is then charged to the output voltage of the DC Pre-Amp.
When the Chopper is conducting the output from TR5/TR6, which is defined as a current proportional to the voltage of C17, is connected to the O/P Amp via TR15. During this period C9 in the Output Amplifier changes at a rate proportional to the dc or low frequency voltage appearing at the i/P Amp. input during the preceding period when the Chopper is not conducting.
NOTE: The voltage at the Input Amp. input includes the difference between the voltage stored on C9 in the Output Amp. and dc offset due to the AC Pre-Amp. and IC1, connected from the feedback from the Amp. output via the Lo input and the voltage source being measured.
OUTPUT AMP.
C9 stores the output of the Demodulator.
TO INPUT AMPLIFIER CONNECTION (SEE ORG 5)
PART OF BOARD 6 (MOTHER BOARD)
μV OFFSET
Front Panel Control.
Enables small internal and external offsets (±15μV) to be compensated for by adding a small dc offset to the Chopper waveform. (See SECTION 1, CONTROLS).
μV OFFSET
RV1
CHOPPER DRIVE
RV1 SET INPUT CURRENT MINIMUM
2.5kHz emitter coupled multivibrator TR12/TR13 drives differential amplifiers TR9/TR10 and TR7/TR8 which drive the Chopper and Demodulator.
RV2 sets the dc bias on G1 of Chopper TR14, and is adjusted to give maximum amplitude chopped waveform at the output of the DC Pre-Amp (TP1). RV1 sets the amplitude of the antiphase Chopper drive signal at G2 of Chopper TR14, and is adjusted to give minimum input current into the Input Amp.
RV2 SET MAX. SQ. WAVE AT TP1

INPUT AMPLIFIER (A200 AND A203) DESCRIPTION 6

Fig. 7.37 Pcb 2 Socket and RV1 (μV OFFSET)

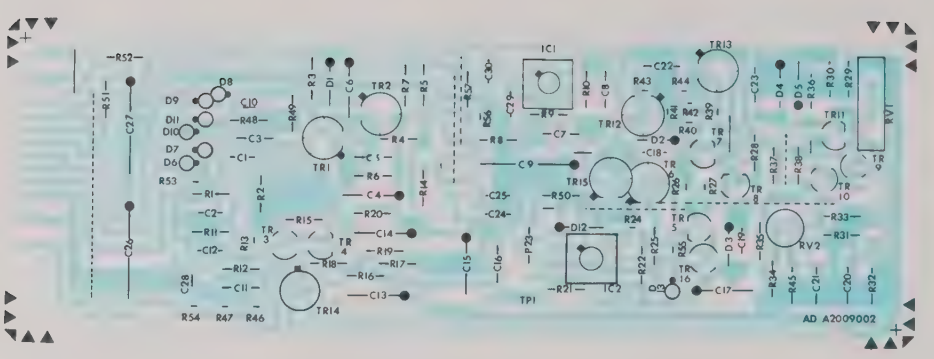


Fig. 7.38 Pcb 2

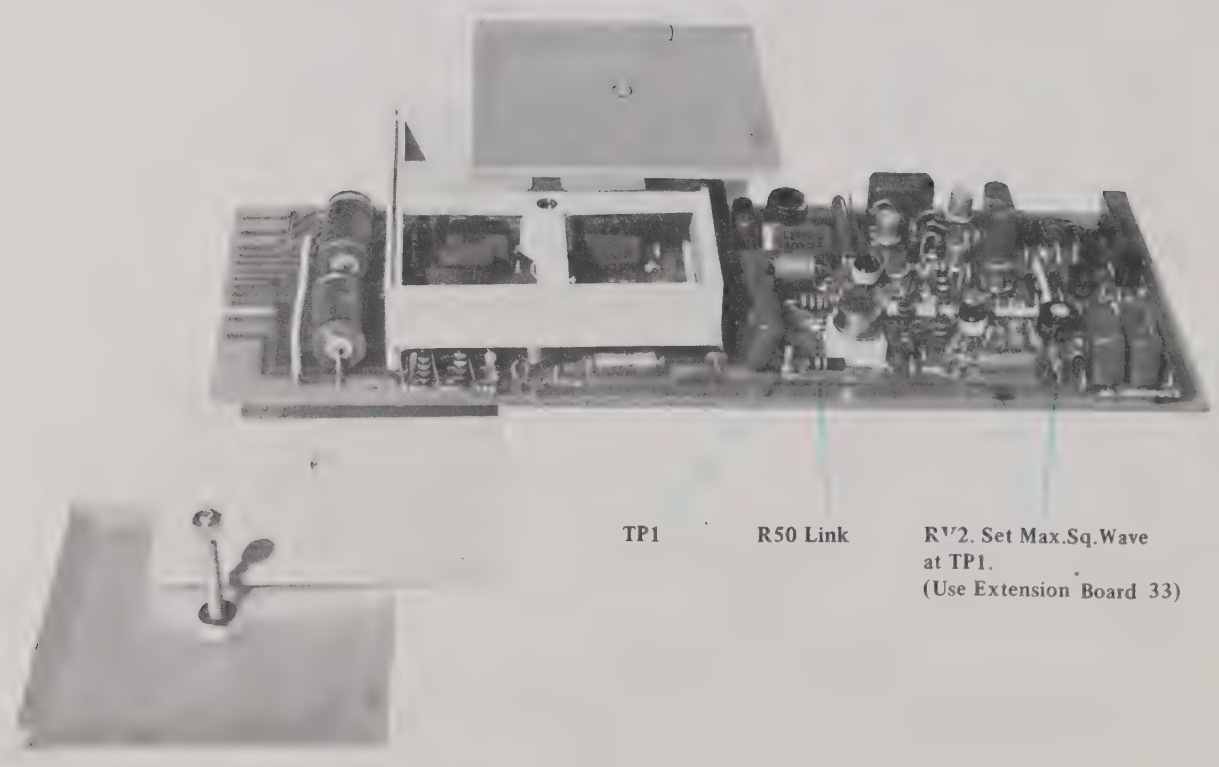
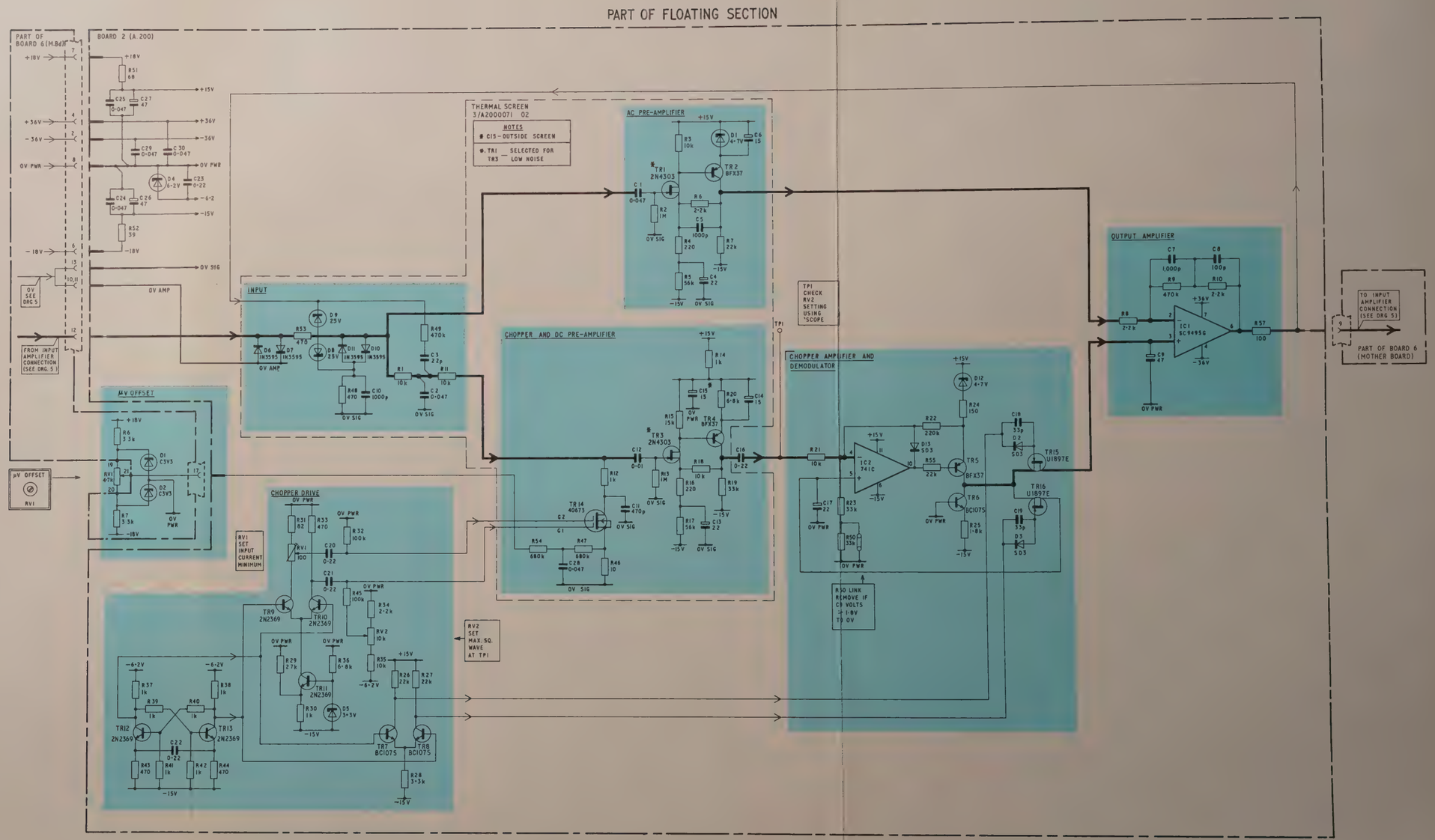


Fig. 7.40 Pcb 2, (A200, A203)
Thermal Screen Removal

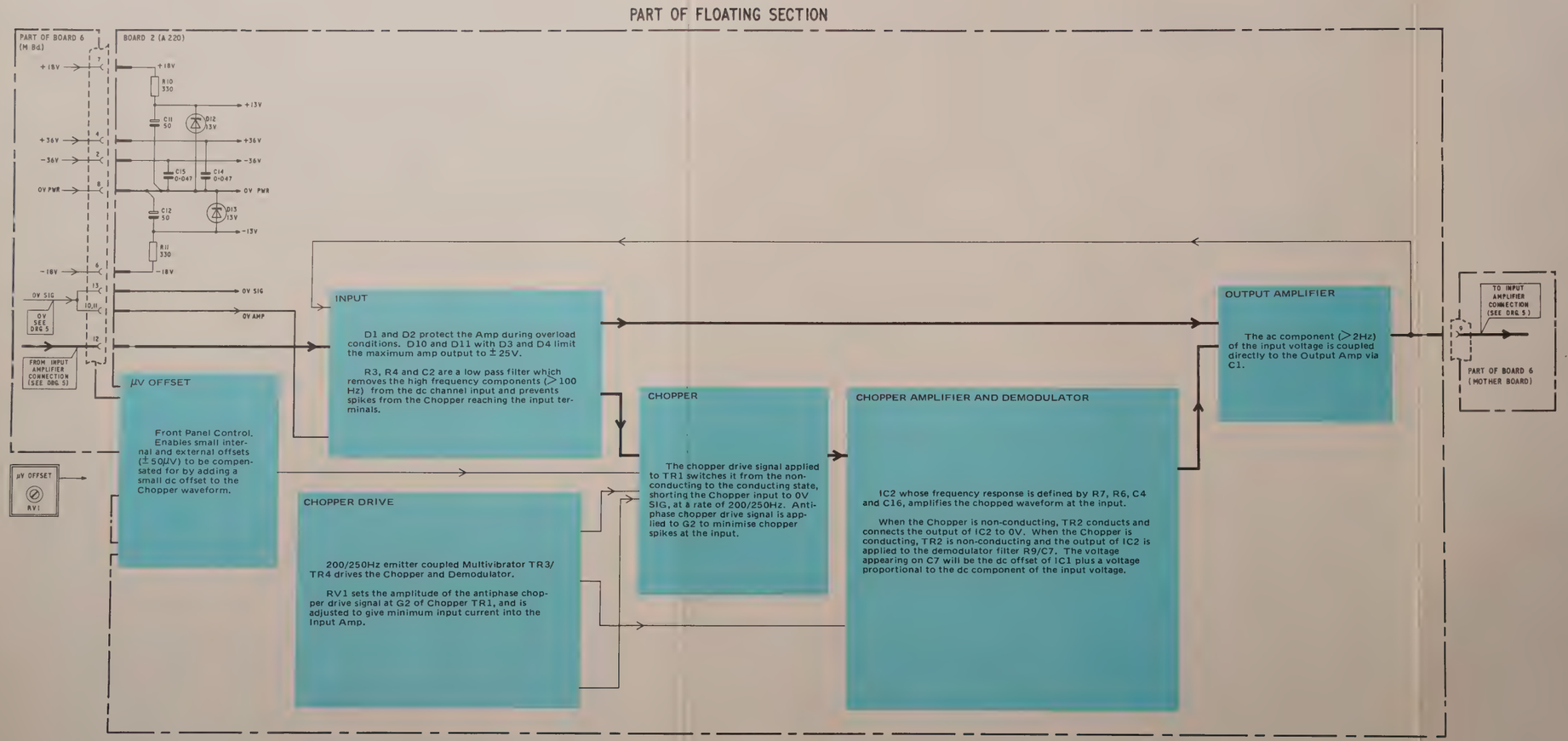


INPUT AMPLIFIER CIRCUIT (1μV)

6

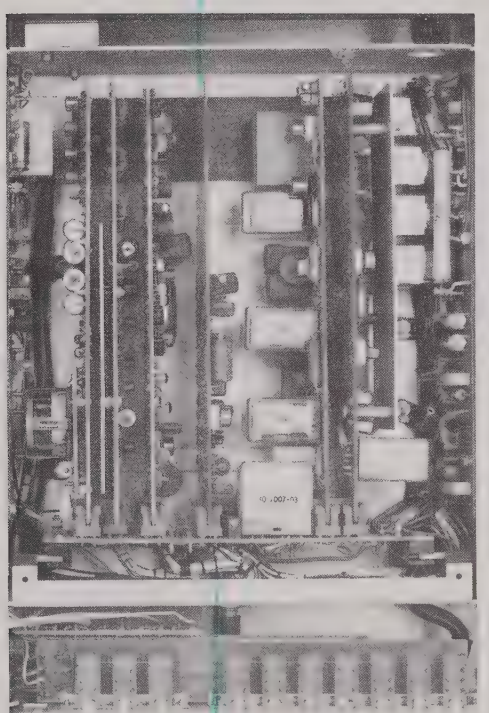
JR/A200/2

7.6.4


PART OF FLOATING SECTION
PART OF BOARD 6 (M Bd)
BOARD 2 (A 220)
+18V
+13V
+36V
-36V
0V PWR
-13V
-18V
0V SIG
0V AMP
0V SEE DRG 5
FROM INPUT AMPLIFIER CONNECTION (SEE DRG 5)
μV OFFSET
RV1
INPUT
D1 and D2 protect the Amp during overload conditions. D10 and D11 with D3 and D4 limit the maximum amp output to ± 25V.
R3, R4 and C2 are a low pass filter which removes the high frequency components (> 100 Hz) from the dc channel input and prevents spikes from the Chopper reaching the input terminals.
μV OFFSET
Front Panel Control. Enables small internal and external offsets (± 50μV) to be compensated for by adding a small dc offset to the Chopper waveform.
CHOPPER
The chopper drive signal applied to TR1 switches it from the non-conducting to the conducting state, shorting the Chopper input to 0V SIG, at a rate of 200/250Hz. Anti-phase chopper drive signal is applied to G2 to minimise chopper spikes at the input.
CHOPPER DRIVE
200/250Hz emitter coupled Multivibrator TR3/TR4 drives the Chopper and Demodulator.
RV1 sets the amplitude of the antiphase chopper drive signal at G2 of Chopper TR1, and is adjusted to give minimum input current into the input Amp.
CHOPPER AMPLIFIER AND DEMODULATOR
IC2 whose frequency response is defined by R7, R6, C4 and C16, amplifies the chopped waveform at the input.
When the Chopper is non-conducting, TR2 conducts and connects the output of IC2 to 0V. When the Chopper is conducting, TR2 is non-conducting and the output of IC2 is applied to the demodulator filter R9/C7. The voltage appearing on C7 will be the dc offset of IC1 plus a voltage proportional to the dc component of the input voltage.
OUTPUT AMPLIFIER
The ac component (> 2Hz) of the input voltage is coupled directly to the Output Amp via C1.
TO INPUT AMPLIFIER CONNECTION (SEE DRG 5)
PART OF BOARD 6 (MOTHER BOARD)

INPUT AMPLIFIER (A220 AND A223) DESCRIPTION **7**

Pcb 2 (A220, A223)



RV1 (μV OFFSET)
Front Panel Control

Fig. 7.41 Pcb 2 (A220, A223)

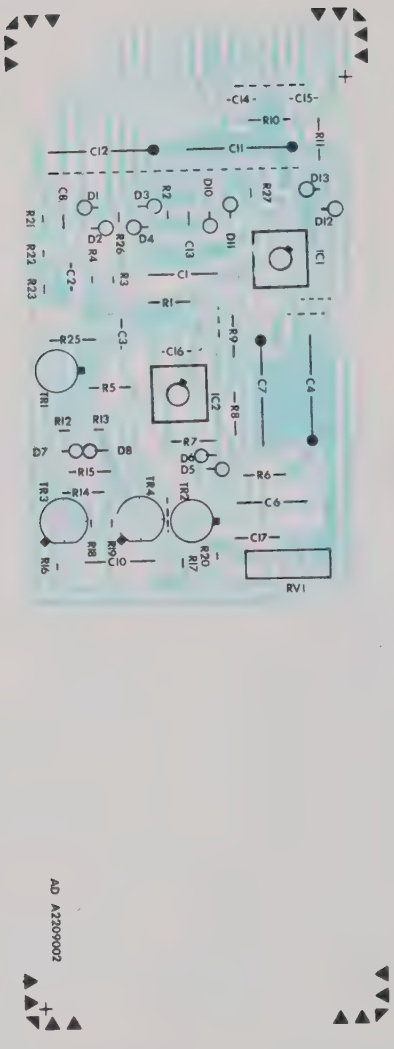
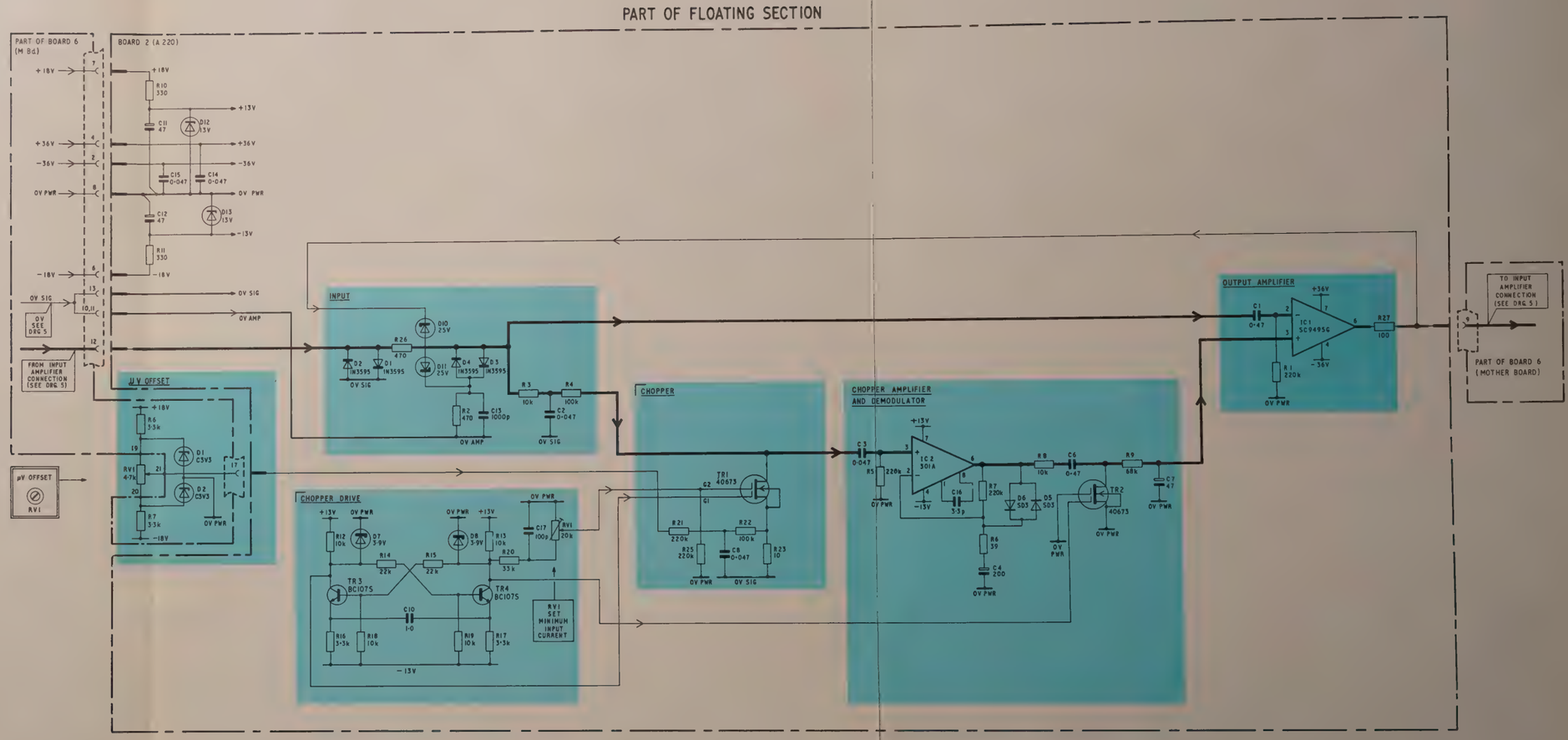
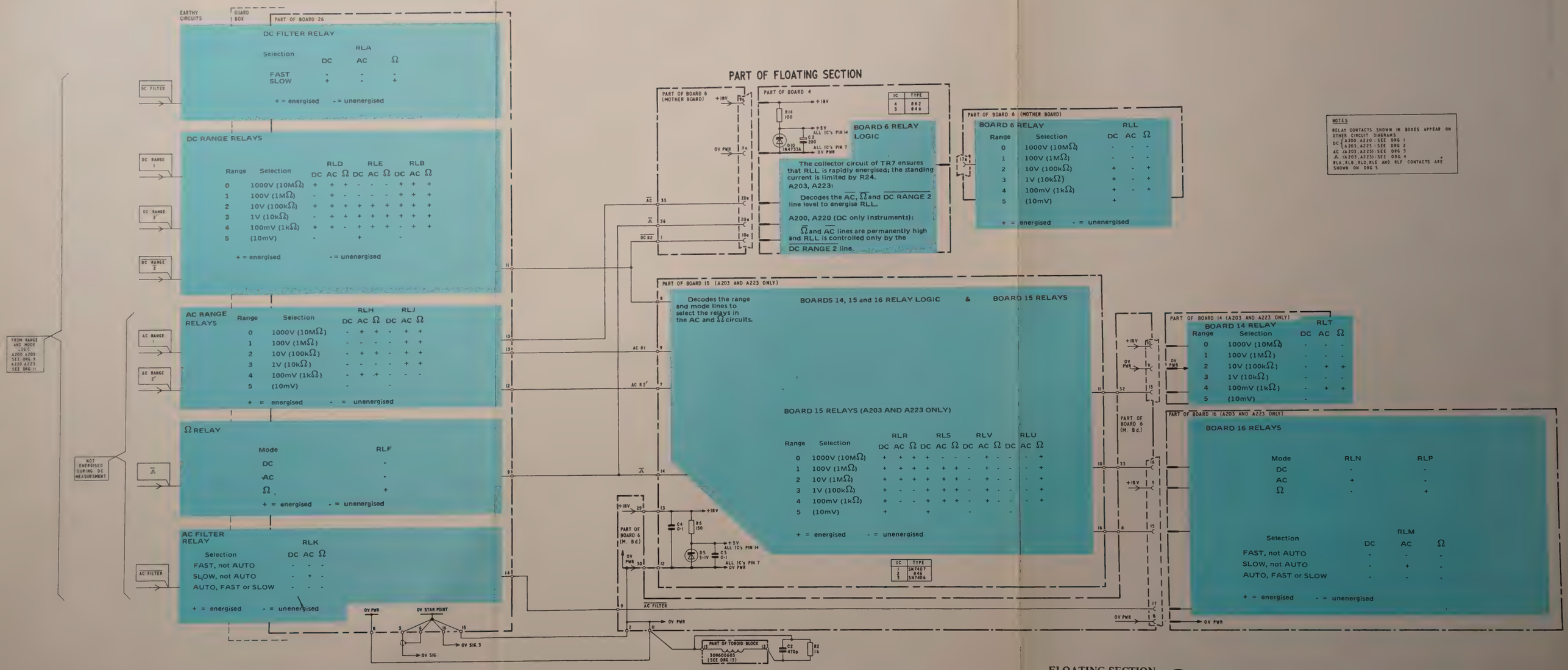


Fig. 7.42 Pcb 2 A220, A223



INPUT AMPLIFIER (10μV) CIRCUIT 7


PART OF FLOATING SECTION
EARTHY CIRCUITS
GUARD BOX
PART OF BOARD 26
DC FILTER RELAY
Selection
RLA
DC AC Ω
FAST - - -
SLOW + - +
+ = energised - = unenergised
DC FILTER
DC RANGE RELAYS
Range Selection
RLD DC AC Ω
RLE DC AC Ω
RLB DC AC Ω
0 1000V (10MΩ) + + + - - - + + +
1 100V (1MΩ) - + - - - - + + +
2 10V (100kΩ) + + + + + + + + +
3 1V (10kΩ) - + + + + + + + +
4 100mV (1kΩ) + + - + + + - + +
5 (10mV) - + -
+ = energised - = unenergised
DC RANGE 1
DC RANGE 2'
DC RANGE 2
AC RANGE RELAYS
Range Selection
RLH DC AC Ω
RLJ DC AC Ω
0 1000V (10MΩ) - + + - + +
1 100V (1MΩ) - - - - + +
2 10V (100kΩ) - + + - + +
3 1V (10kΩ) - - - - + +
4 100mV (1kΩ) - + + - - -
5 (10mV) - -
+ = energised - = unenergised
AC RANGE 1
AC RANGE 2'
Ω RELAY
Mode RLF
DC -
AC -
Ω +
+ = energised - = unenergised
AC FILTER RELAY
Selection RLK DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
+ = energised - = unenergised
AC FILTER
FROM RANGE AND MODE LOGIC A200 A203 SEE DRG 9 A220 A223 SEE DRG 11
NOT ENERGISED DURING DC MEASUREMENT
PART OF BOARD 6 (MOTHER BOARD)
+18V
0V PWR
PART OF BOARD 4
R14 100
D10 (IN4733A)
C2 200
+5V ALL IC's PIN 14
0V PWR
IC TYPE
4 846
5 846
BOARD 6 RELAY LOGIC
The collector circuit of TR7 ensures that RLL is rapidly energised; the standing current is limited by R24.
A203, A223:
Decodes the AC, Ω and DC RANGE 2 line level to energise RLL.
A200, A220 (DC only instruments):
Ω and AC lines are permanently high and RLL is controlled only by the DC RANGE 2 line.
PART OF BOARD 6 (MOTHER BOARD)
BOARD 6 RELAY
Range Selection
RLL DC AC Ω
0 1000V (10MΩ) - - -
1 100V (1MΩ) - - -
2 10V (100kΩ) + - +
3 1V (10kΩ) + - +
4 100mV (1kΩ) + - +
5 (10mV) +
+ = energised - = unenergised
NOTES
RELAY CONTACTS SHOWN IN BOXES APPEAR ON OTHER CIRCUIT DIAGRAMS
DC (A200,A220 : SEE ORG 1
(A203,A223 : SEE ORG 2
AC (A203,A223) : SEE ORG 3
Ω (A203,A223) : SEE ORG 4
PLA,PLB,PLD,PLE AND PLF CONTACTS ARE SHOWN ON ORG 5
PART OF BOARD 15 (A203 AND A223 ONLY)
Decodes the range and mode lines to select the relays in the AC and Ω circuits.
BOARDS 14, 15 and 16 RELAY LOGIC & BOARD 15 RELAYS
BOARD 15 RELAYS (A203 AND A223 ONLY)
Range Selection
RLR DC AC Ω
RLS DC AC Ω
RLV DC AC Ω
RLU DC AC Ω
0 1000V (10MΩ) + + + + - - - + - - - +
1 100V (1MΩ) + + + + + + - + - - - +
2 10V (1MΩ) + + + + + + - + - - - +
3 1V (100kΩ) + - - + + + - + - - - +
4 100mV (1kΩ) + - - + + + - + - - - +
5 (10mV) + + - -
+ = energised - = unenergised
IC TYPE
1 SN7407
2 846
3 SN7406
AC R1
AC R2'
DC R2
AC
AC FILTER
PART OF BOARD 6 (M. Bd.)
C4 0-1
R6 150
D5 5-1V
C5 0-1
+5V ALL IC's PIN 14
ALL IC's PIN 7 0V PWR
0V STAR POINT
0V SIG
0V SIG.3
PART OF TOROID BLOCK 3096009607 (SEE DRG 13)
C2 470p
R2 1k
PART OF BOARD 14 (A203 AND A223 ONLY)
BOARD 14 RELAY
Range Selection
RLT DC AC Ω
0 1000V (10MΩ) - - -
1 100V (1MΩ) - - -
2 10V (100kΩ) - + +
3 1V (10kΩ) - - -
4 100mV (1kΩ) - + +
5 (10mV) -
PART OF BOARD 16 (A203 AND A223 ONLY)
BOARD 16 RELAYS
Mode RLN RLP
DC - -
AC + -
Ω - +
Selection
RLM DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
+ = energised - = unenergised

FLOATING SECTION
RELAYS
DESCRIPTION

8

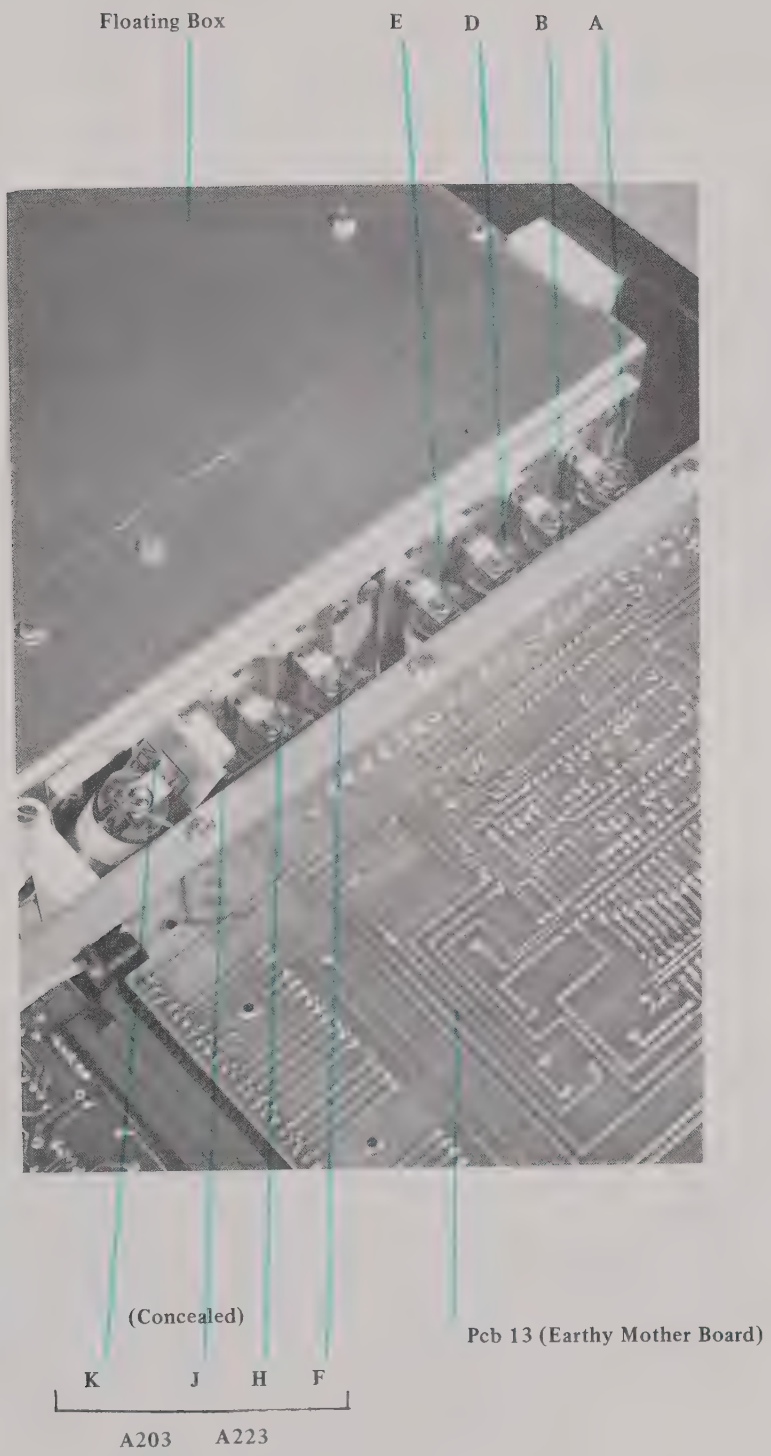


Fig. 7.44 Reed Relay Coil Removal. Underside View.

Fig. 7.44 Shows Relay Coil K and housing unscrewed from the Floating Box.

To remove the coil from the contact housing, remove both spire fasteners and the core rod.

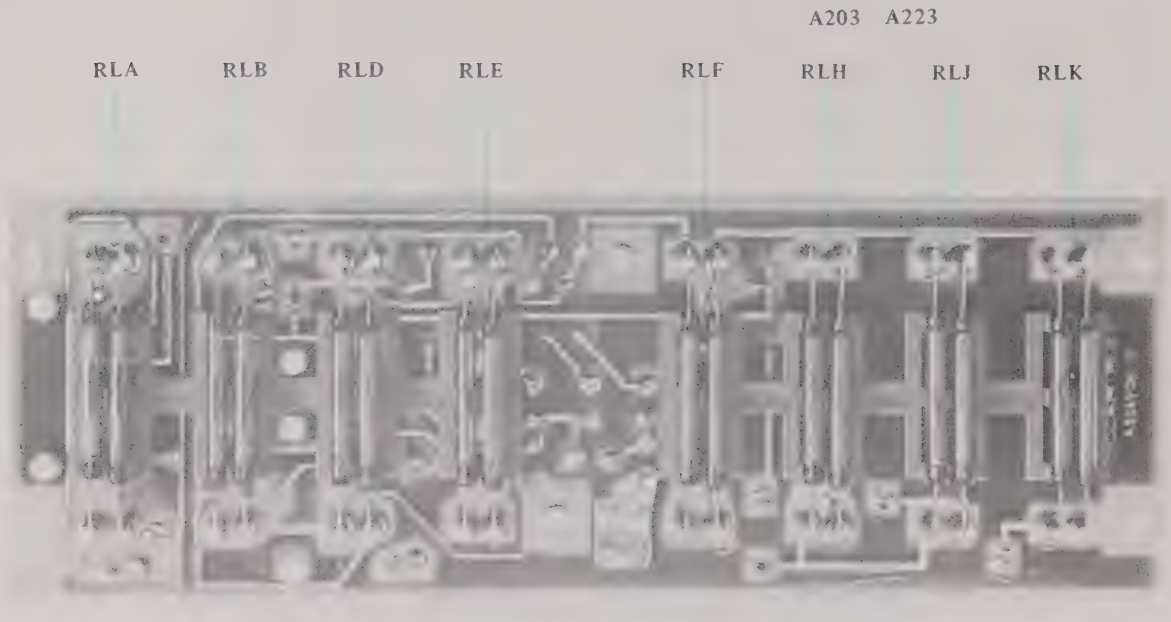


Fig. 7.45 Pcb 26 Copper Side, and Reed Relay Contacts

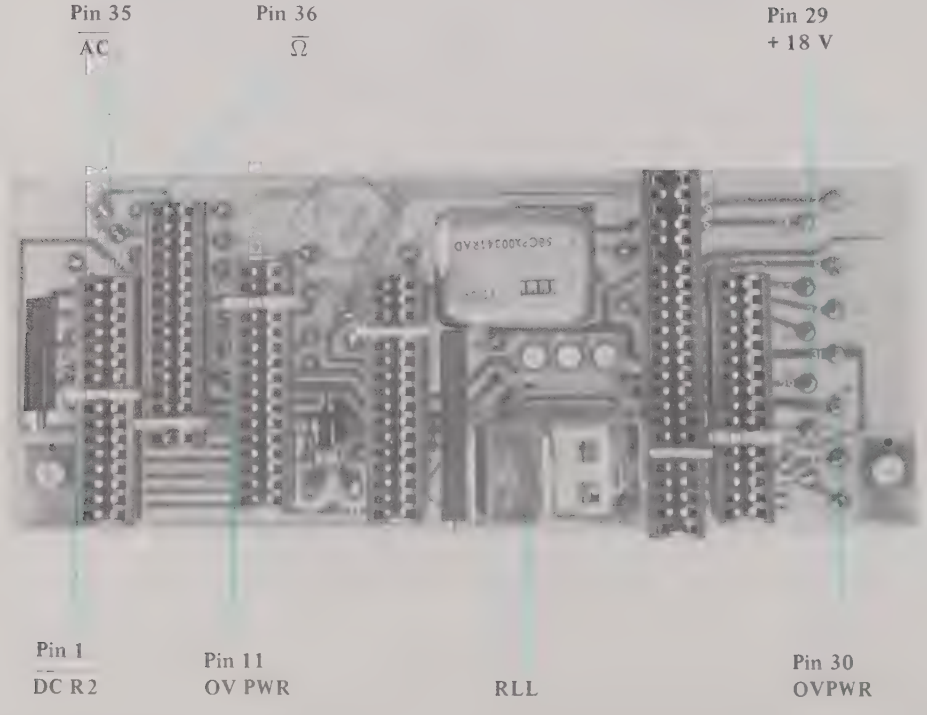


Fig. 7.46 Pcb 6 Mother Board

Fig. 7.47 Pcb 14 RLT

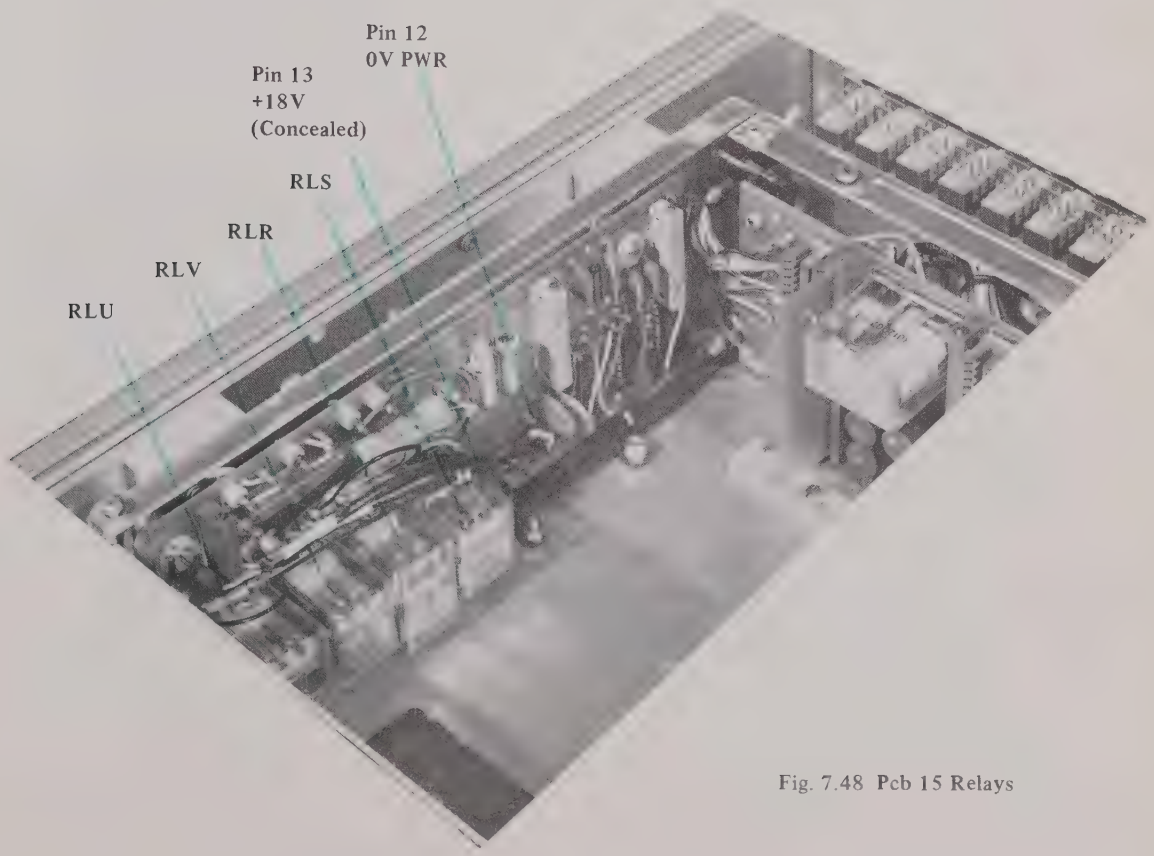


Fig. 7.48 Pcb 15 Relays

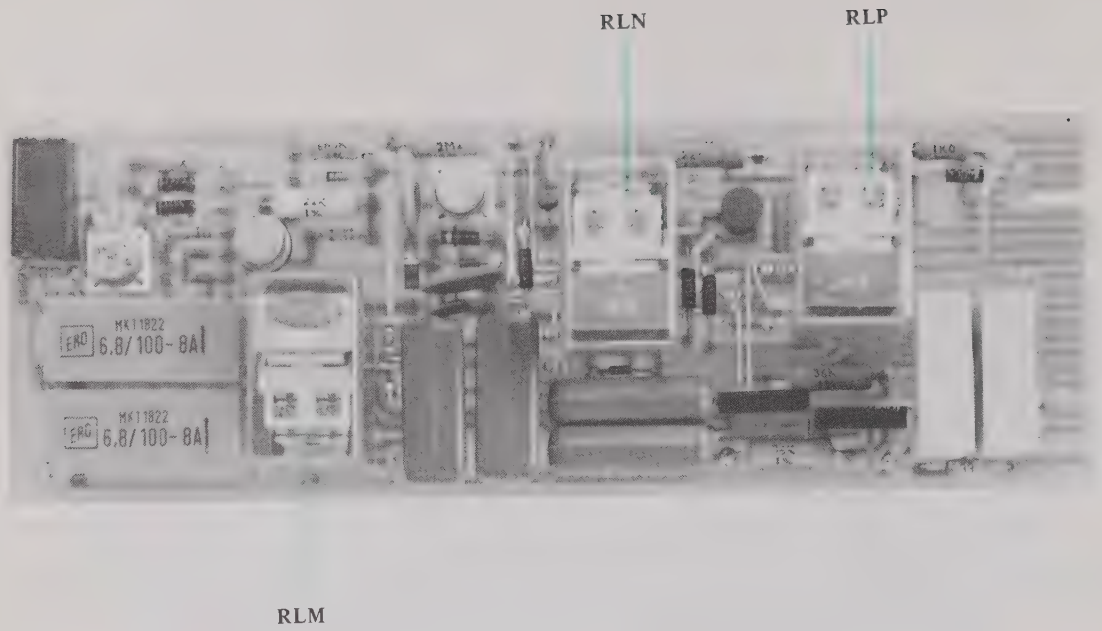


Fig. 7.49 Pcb 16 Relays

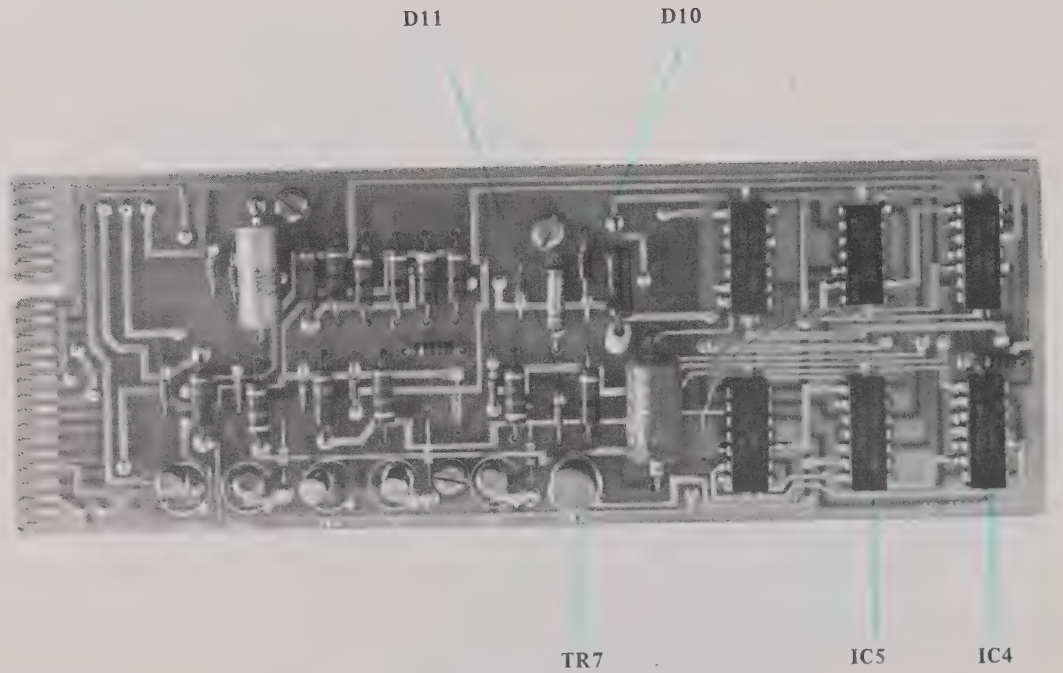
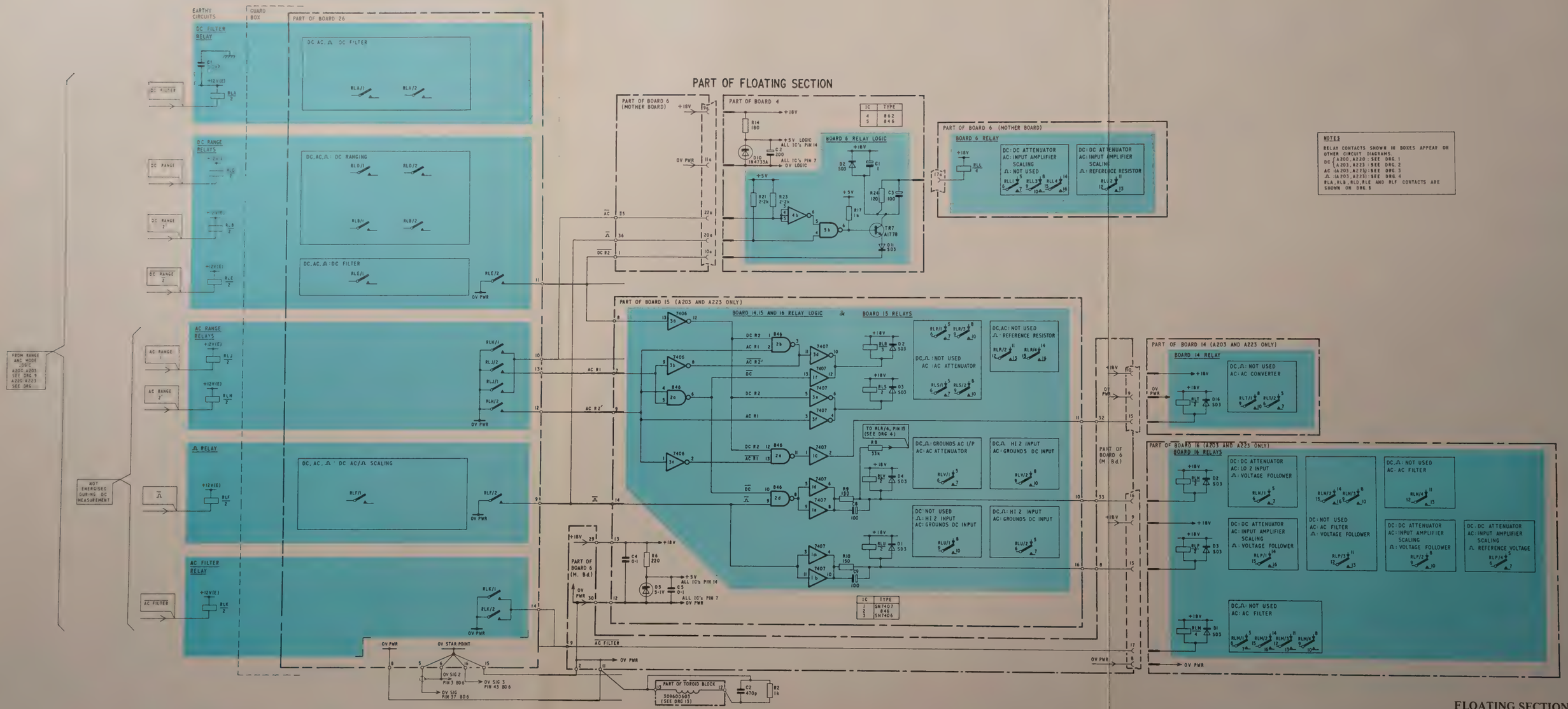


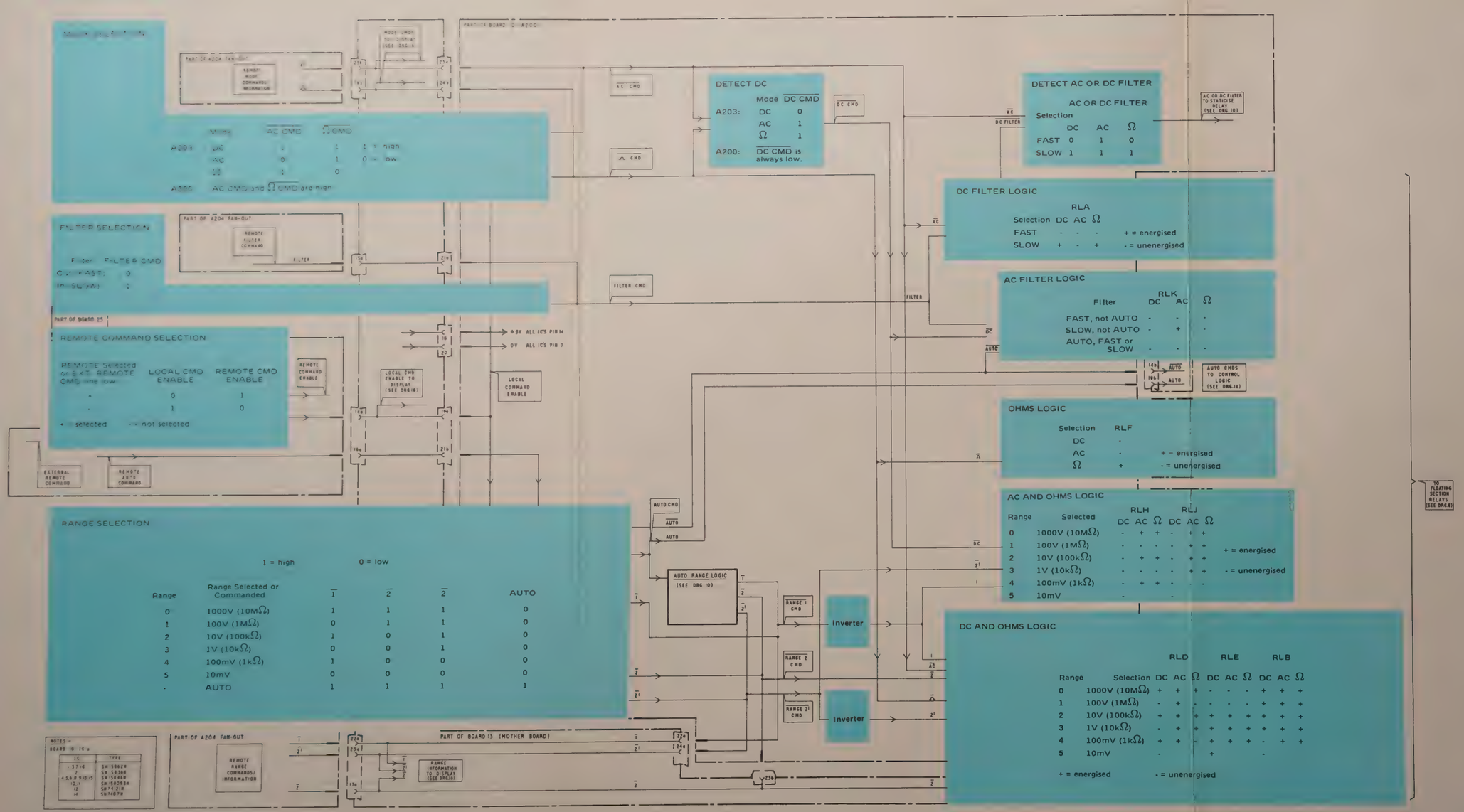
Fig.7.50 Pcb 4 RLL Drive


PART OF FLOATING SECTION
EARTHY CIRCUITS
GUARD BOX
PART OF BOARD 26
DC FILTER RELAY
DC AC, Ω DC FILTER
DC RANGE RELAYS
DC, AC, Ω : DC RANGING
DC, AC, Ω : DC FILTER
AC RANGE RELAYS
Ω RELAY
DC, AC, Ω : DC AC/Ω SCALING
AC FILTER RELAY
FROM RANGE AND MODE SWS A202, A203 SEE DRG 9 A202, A223 SEE DRG
NOT ENERGISED DURING DC MEASUREMENT
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 4
BOARD 6 RELAY LOGIC
BOARD 6 RELAY
DC: DC ATTENUATOR AC: INPUT AMPLIFIER SCALING Ω: NOT USED
DC: DC ATTENUATOR AC: INPUT AMPLIFIER SCALING Ω: REFERENCE RESISTOR
PART OF BOARD 15 (A203 AND A223 ONLY)
BOARD 14,15 AND 16 RELAY LOGIC & BOARD 15 RELAYS
DC,AC: NOT USED Ω: REFERENCE RESISTOR
DC,Ω: NOT USED AC: AC ATTENUATOR
DC,Ω: GROUNDS AC I/P AC: AC ATTENUATOR
DC,Ω HI 2 INPUT AC: GROUNDS DC INPUT
DC: NOT USED Ω: HI 2 INPUT AC: GROUNDS DC INPUT
DC,Ω: HI 2 INPUT AC: GROUNDS DC INPUT
TO RLR/4, PIN 15 (SEE DRG 4)
PART OF BOARD 14 (A203 AND A223 ONLY)
BOARD 14 RELAY
DC,Ω: NOT USED AC: AC CONVERTER
PART OF BOARD 16 (A203 AND A223 ONLY)
BOARD 16 RELAYS
DC: DC ATTENUATOR AC: LO 2 INPUT Ω: VOLTAGE FOLLOWER
DC: DC ATTENUATOR AC: INPUT AMPLIFIER SCALING Ω: VOLTAGE FOLLOWER
DC: NOT USED AC: AC FILTER Ω: VOLTAGE FOLLOWER
DC,Ω: NOT USED AC: AC FILTER
DC: DC ATTENUATOR AC: INPUT AMPLIFIER SCALING Ω: VOLTAGE FOLLOWER
DC: DC ATTENUATOR AC: INPUT AMPLIFIER SCALING Ω REFERENCE VOLTAGE
DC,Ω: NOT USED AC: AC FILTER
PART OF BOARD 6 (M. Bd.)
OV STAR POINT
PART OF TOROID BLOCK 309600603 (SEE DRG 13)
NOTES
RELAY CONTACTS SHOWN IN BOXES APPEAR ON OTHER CIRCUIT DIAGRAMS.
DC (A200, A220 : SEE DRG. 1
A203, A223 : SEE DRG. 2
AC (A203, A223) : SEE DRG. 3
Ω (A203, A223) : SEE DRG. 4
RLA, RLB, RLD, RLE AND RLF CONTACTS ARE SHOWN ON DRG. 5

FLOATING SECTION RELAYS CIRCUIT 8

JR/A200/2

7.8.


DETECT DC
Mode DC CMD
A203: DC 0
AC 1
Ω 1
A200: DC CMD is always low.
DETECT AC OR DC FILTER
AC OR DC FILTER
Selection DC AC Ω
FAST 0 1 0
SLOW 1 1 1
DC FILTER LOGIC
RLA
Selection DC AC Ω
FAST - - - + = energised
SLOW + - + - = unenergised
AC FILTER LOGIC
RLK
Filter DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
OHMS LOGIC
Selection RLF
DC -
AC - + = energised
Ω + - = unenergised
AC AND OHMS LOGIC
RLH RLJ
Range Selected DC AC Ω DC AC Ω
0 1000V (10MΩ) - + + - + +
1 100V (1MΩ) - - - - + +
2 10V (100kΩ) - + + - + +
3 1V (10kΩ) - - - - + +
4 100mV (1kΩ) - + + - - -
5 10mV - -
+ = energised
- = unenergised
DC AND OHMS LOGIC
RLD RLE RLB
Range Selection DC AC Ω DC AC Ω DC AC Ω
0 1000V (10MΩ) + + + - - - + + +
1 100V (1MΩ) - + - - - - + + +
2 10V (100kΩ) + + + + + + + + +
3 1V (10kΩ) - + + + + + + + +
4 100mV (1kΩ) + + - + + + - + +
5 10mV - + -
+ = energised
- = unenergised
FILTER SELECTION
Filter FILTER CMD
FAST 0
SLOW 1
REMOTE COMMAND SELECTION
REMOTE Selected or EXT. REMOTE CMD line low
LOCAL CMD ENABLE
REMOTE CMD ENABLE
0 1
1 0
• = selected - = not selected
RANGE SELECTION
1 = high 0 = low
Range
Range Selected or Commanded
AUTO
0 1000V (10MΩ) 1 1 1 0
1 100V (1MΩ) 0 1 1 0
2 10V (100kΩ) 1 0 1 0
3 1V (10kΩ) 0 0 1 0
4 100mV (1kΩ) 1 0 0 0
5 10mV 0 0 0 0
. AUTO 1 1 1 1
AUTO RANGE LOGIC (SEE DRG 10)
Inverter
Inverter
+5V ALL IC'S PIN 14
0V ALL IC'S PIN 7
AUTO CMDS TO CONTROL LOGIC (SEE DRG.14)
TO FLOATING SECTION RELAYS (SEE DRG.8)
AC OR DC FILTER TO STATICISE DELAY (SEE DRG.10)
EXTERNAL REMOTE COMMAND
REMOTE AUTO COMMAND
REMOTE COMMAND ENABLE
LOCAL CMD ENABLE TO DISPLAY (SEE DRG.16)
LOCAL COMMAND ENABLE
REMOTE FILTER COMMAND
REMOTE RANGE COMMANDS/ INFORMATION
RANGE INFORMATION TO DISPLAY (SEE DRG.16)
PART OF A204 FAN-OUT
PART OF BOARD 25
PART OF BOARD 13 (MOTHER BOARD)

RANGE AND MODE LOGIC (A200 AND A203) DESCRIPTION 9

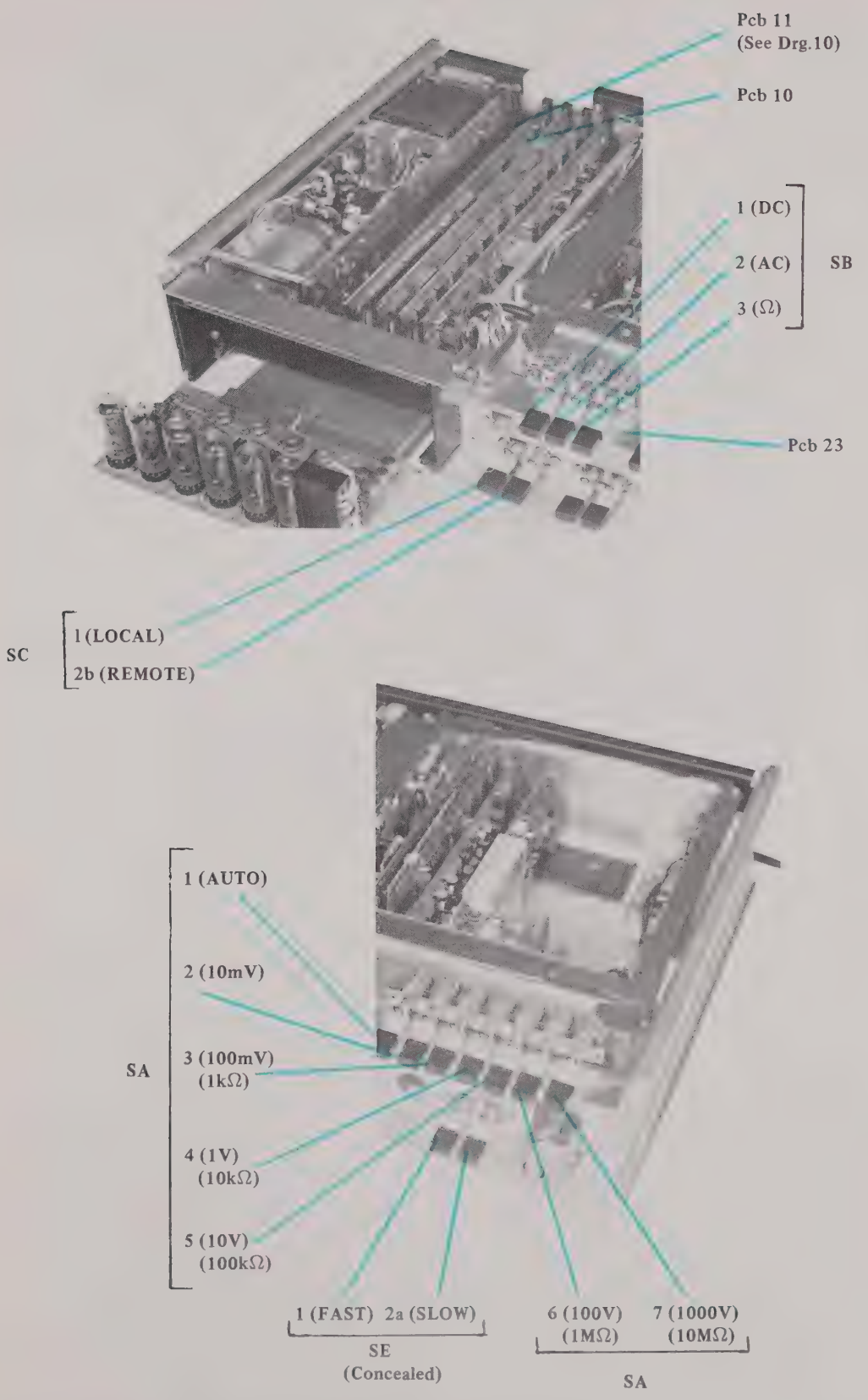


Fig. 7.51 Pcb 10 and Switch Location

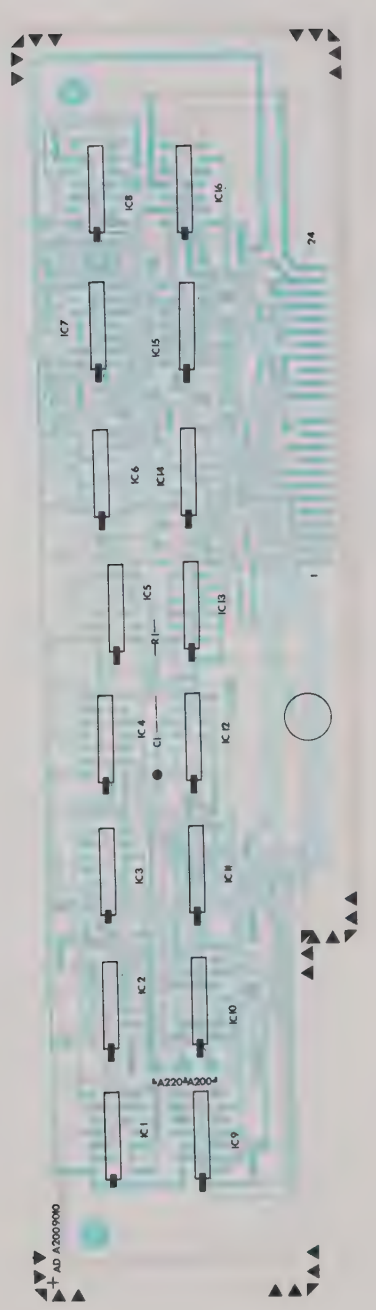
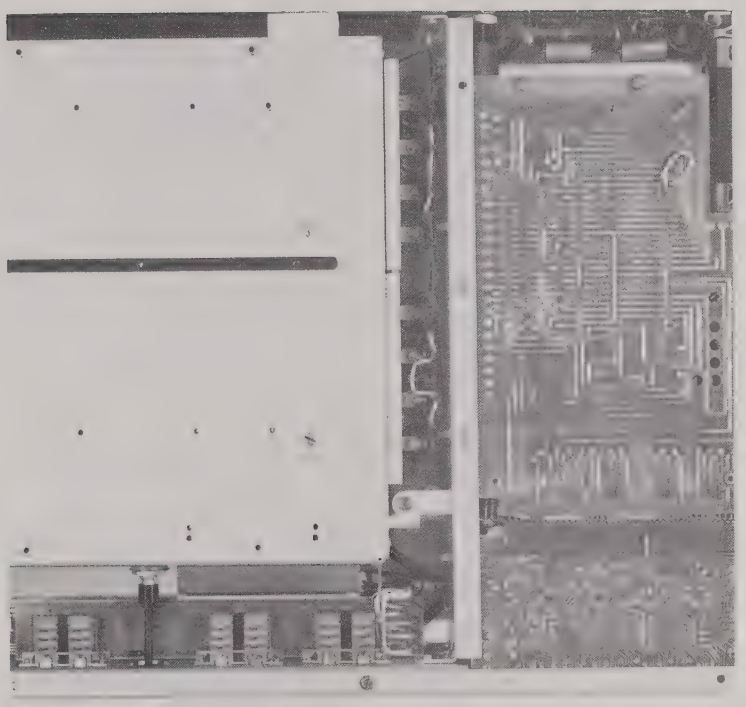


Fig. 7.52 Pcb 10 A200, A203

Pcb 13
(Earthy Mother Board)

Relay
Coils

A
B
D
E
F
H
J
K



Pcb 25

2a (SLOW) 1 (FAST) — SE

2b (REMOTE) 1 (LOCAL) — SC

Pcb 7

Fig. 7.54 Underside View
(Relay F, H, J, K, on A203)

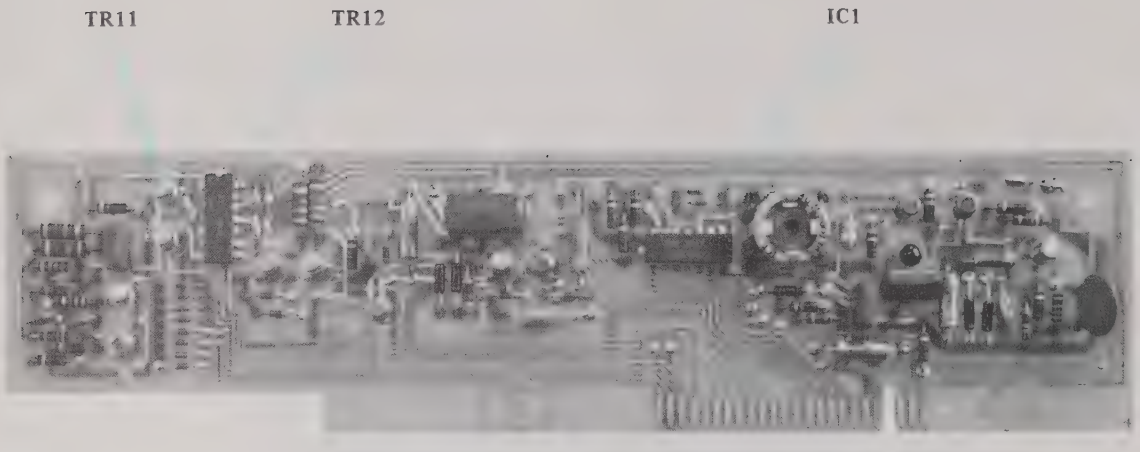


Fig. 7.55 Pcb 8 RLB and RLE Drive

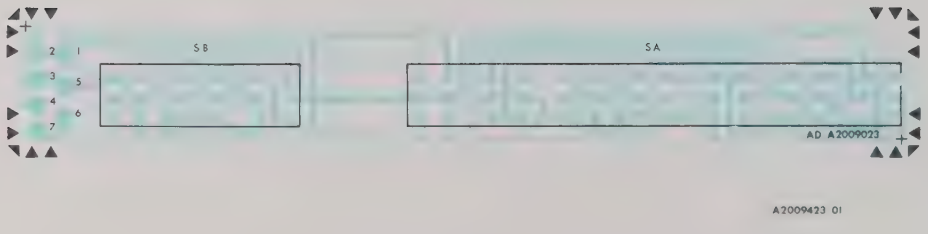
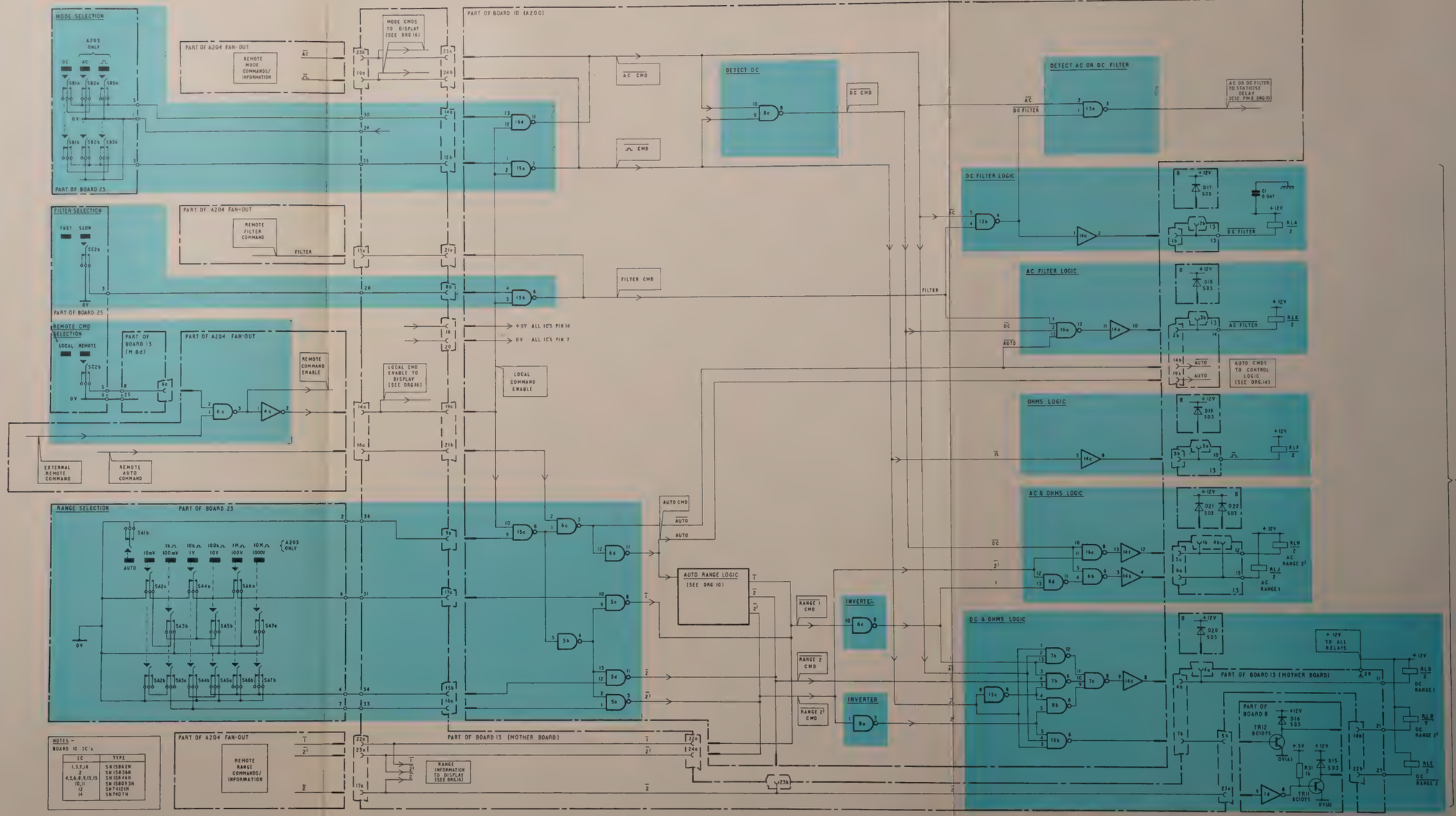
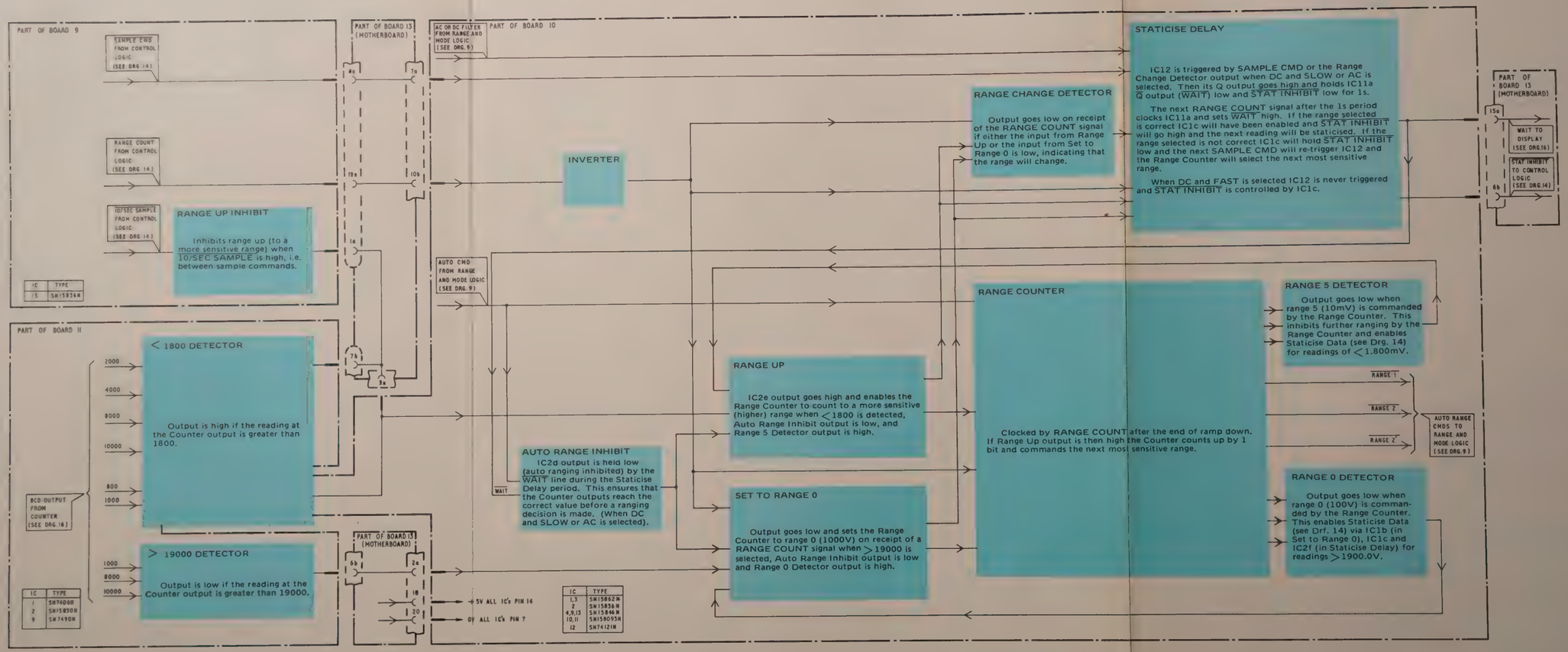


Fig. 7.56 Pcb 23



RANGE AND MODE LOGIC (A200 AND A203) CIRCUIT 9


PART OF BOARD 9
SAMPLE CMD FROM CONTROL LOGIC (SEE DRG 14)
RANGE COUNT FROM CONTROL LOGIC (SEE DRG 14)
10/SEC SAMPLE FROM CONTROL LOGIC (SEE DRG 14)
RANGE UP INHIBIT
Inhibits range up (to a more sensitive range) when 10/SEC SAMPLE is high, i.e. between sample commands.
IC TYPE
15 SN15836N
PART OF BOARD 13 (MOTHERBOARD)
4a
7a
13a
10b
1a
PART OF BOARD 10
AC OR DC FILTER FROM RANGE AND MODE LOGIC (SEE DRG. 9)
INVERTER
AUTO CMD FROM RANGE AND MODE LOGIC (SEE DRG. 9)
PART OF BOARD 11
< 1800 DETECTOR
Output is high if the reading at the Counter output is greater than 1800.
2000
4000
8000
10000
800
1000
BCD OUTPUT FROM COUNTER (SEE DRG 16)
7b
3a
> 19000 DETECTOR
Output is low if the reading at the Counter output is greater than 19000.
1000
8000
10000
IC TYPE
1 SN7406N
2 SN15830N
9 SN7490N
PART OF BOARD 13 (MOTHERBOARD)
6b
2a
1a
20
+5V ALL IC's PIN 14
0V ALL IC's PIN 7
IC TYPE
1,3 SN15862N
2 SN15836N
4,9,13 SN15846N
10,11 SN15893N
12 SN7412IN
RANGE CHANGE DETECTOR
Output goes low on receipt of the RANGE COUNT signal if either the input from Range Up or the input from Set to Range 0 is low, indicating that the range will change.
STATICISE DELAY
IC12 is triggered by SAMPLE CMD or the Range Change Detector output when DC and SLOW or AC is selected. Then its Q output goes high and holds IC11a Q output (WAIT) low and STAT INHIBIT low for 1s.
The next RANGE COUNT signal after the 1s period clocks IC11a and sets WAIT high. If the range selected is correct IC1c will have been enabled and STAT INHIBIT will go high and the next reading will be staticised. If the range selected is not correct IC1c will hold STAT INHIBIT low and the next SAMPLE CMD will re-trigger IC12 and the Range Counter will select the next most sensitive range.
When DC and FAST is selected IC12 is never triggered and STAT INHIBIT is controlled by IC1c.
PART OF BOARD 13 (MOTHERBOARD)
15a
6b
WAIT TO DISPLAY (SEE DRG.16)
STAT INHIBIT TO CONTROL LOGIC (SEE DRG.14)
RANGE UP
IC2e output goes high and enables the Range Counter to count to a more sensitive (higher) range when < 1800 is detected, Auto Range Inhibit output is low, and Range 5 Detector output is high.
AUTO RANGE INHIBIT
IC2d output is held low (auto ranging inhibited) by the WAIT line during the Staticise Delay period. This ensures that the Counter outputs reach the correct value before a ranging decision is made. (When DC and SLOW or AC is selected).
WAIT
SET TO RANGE 0
Output goes low and sets the Range Counter to range 0 (1000V) on receipt of a RANGE COUNT signal when > 19000 is selected, Auto Range Inhibit output is low and Range 0 Detector output is high.
RANGE COUNTER
Clocked by RANGE COUNT after the end of ramp down. If Range Up output is then high the Counter counts up by 1 bit and commands the next most sensitive range.
RANGE 5 DETECTOR
Output goes low when range 5 (10mV) is commanded by the Range Counter. This inhibits further ranging by the Range Counter and enables Staticise Data (see Drg. 14) for readings of < 1.800mV.
RANGE 1
RANGE 2
RANGE 4
AUTO RANGE CMDS TO RANGE AND MODE LOGIC (SEE DRG.9)
RANGE 0 DETECTOR
Output goes low when range 0 (100V) is commanded by the Range Counter. This enables Staticise Data (see Drf. 14) via IC1b (in Set to Range 0), IC1c and IC2f (in Staticise Delay) for readings > 1900.0V.

AUTO RANGE LOGIC DESCRIPTION 10

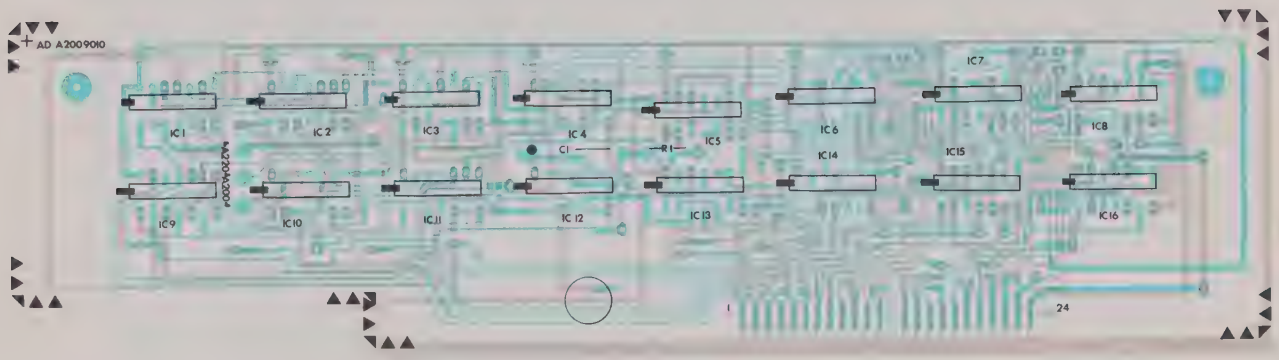


Fig.7.58 Pcb 10 A200, A203

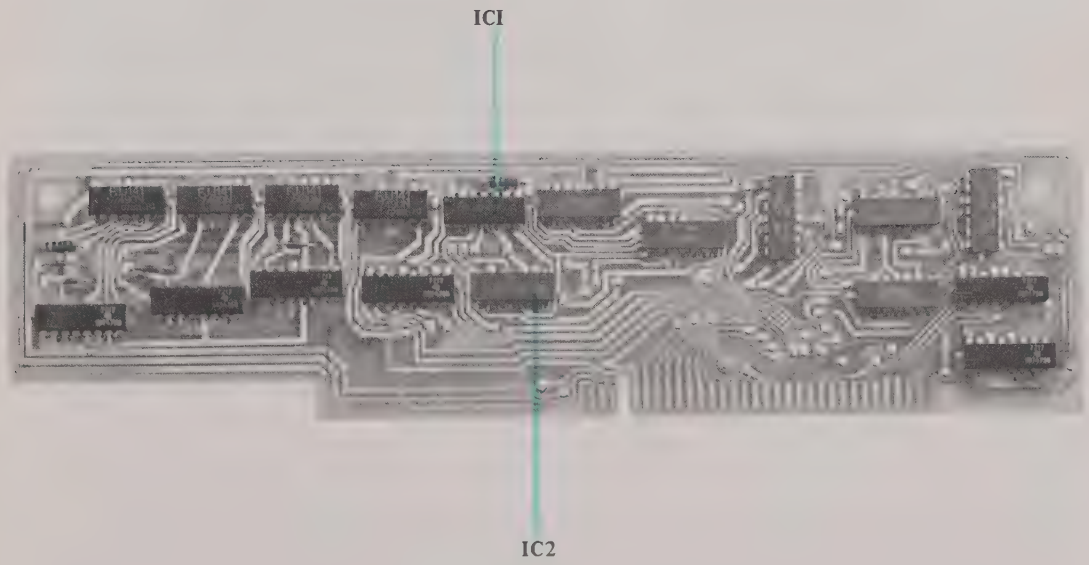
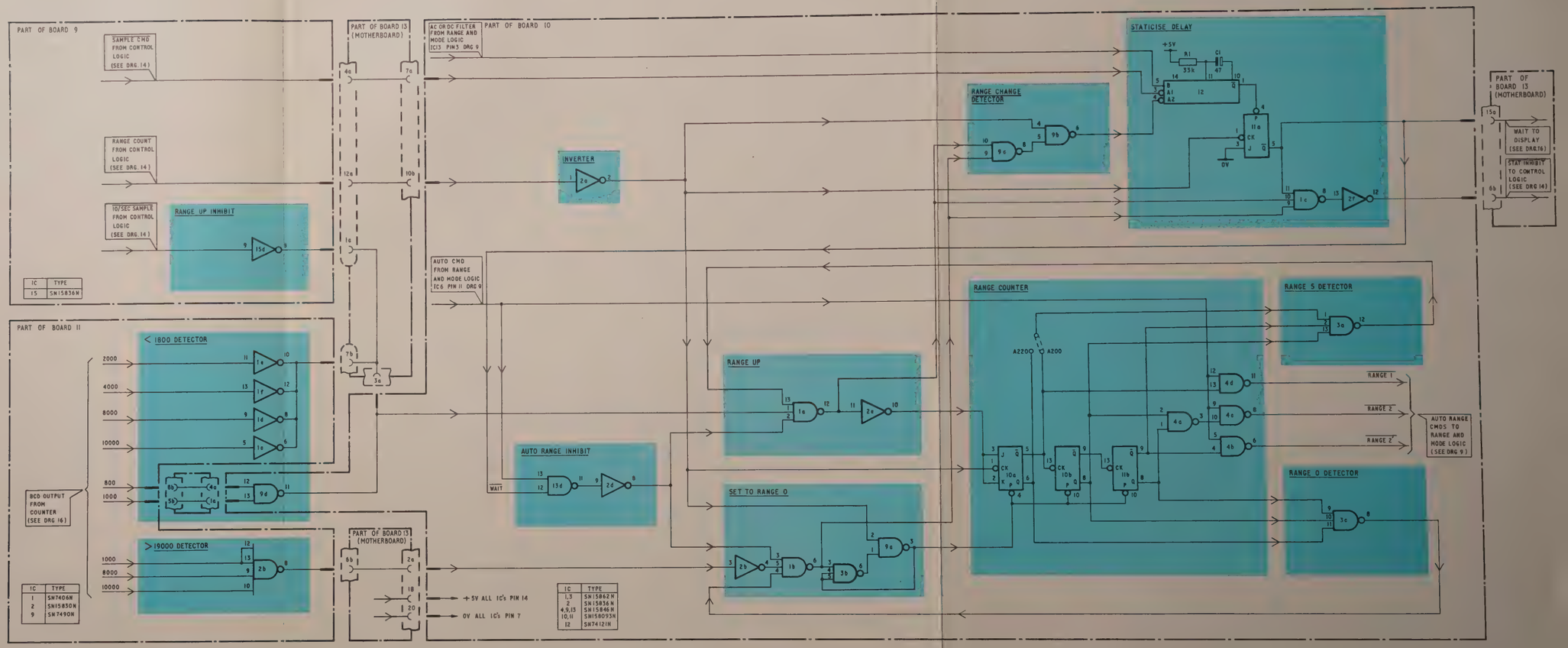
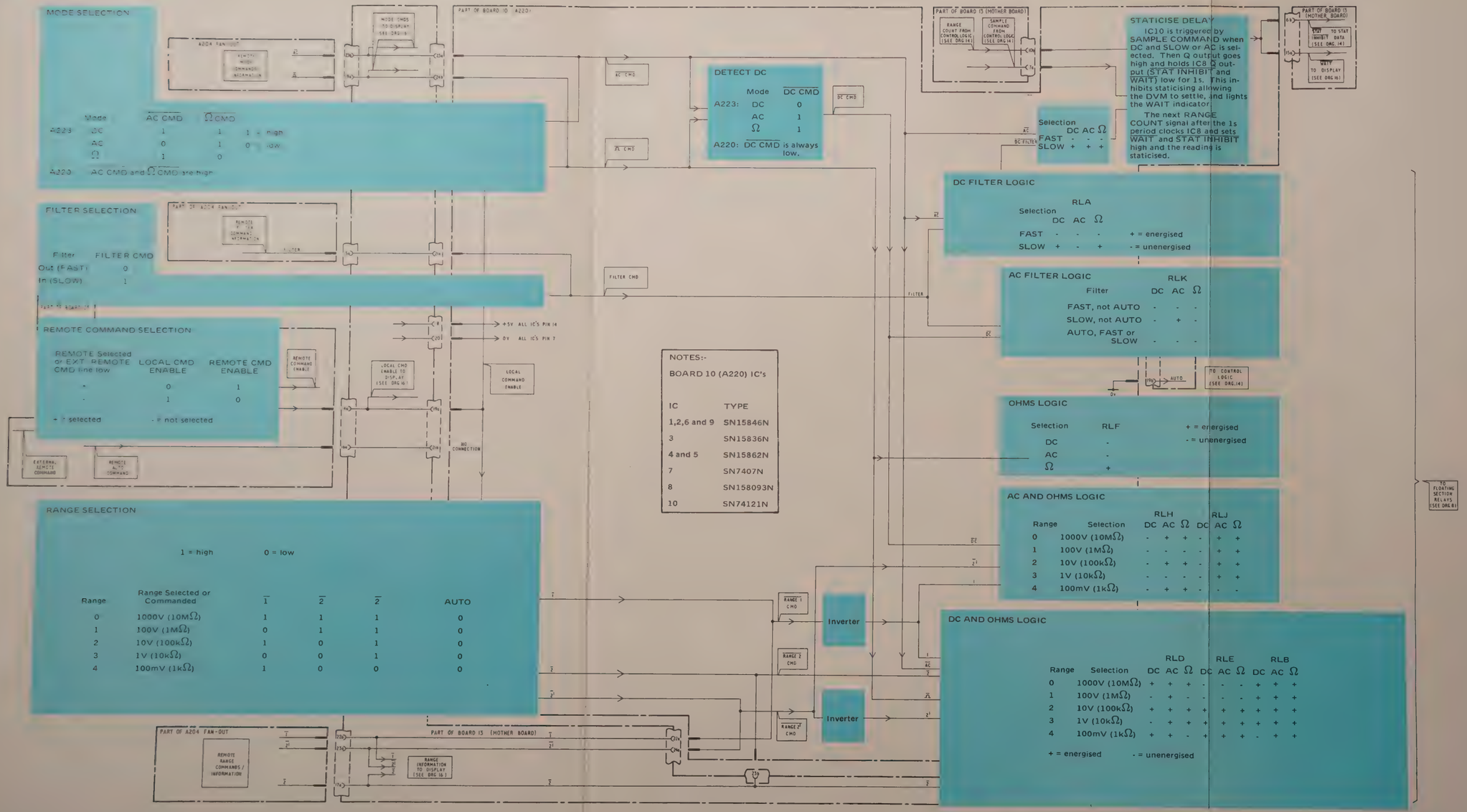


Fig.7.60 Pcb 11, I C's 1 and 2



AUTO RANGE LOGIC CIRCUIT 10


MODE SELECTION
Mode AC CMD Ω CMD
A223: DC 1 1 1 = high
AC 0 1 0 = low
Ω 1 0
A220: AC CMD and Ω CMD are high
FILTER SELECTION
Filter FILTER CMD
Out (FAST) 0
In (SLOW) 1
REMOTE COMMAND SELECTION
REMOTE Selected or EXT REMOTE CMD line low
LOCAL CMD ENABLE
REMOTE CMD ENABLE
- 0 1
- 1 0
+ = selected - = not selected
RANGE SELECTION
1 = high 0 = low
Range Range Selected or Commanded 1 2 2 AUTO
0 1000V (10MΩ) 1 1 1 0
1 100V (1MΩ) 0 1 1 0
2 10V (100kΩ) 1 0 1 0
3 1V (10kΩ) 0 0 1 0
4 100mV (1kΩ) 1 0 0 0
DETECT DC
Mode DC CMD
A223: DC 0
AC 1
Ω 1
A220: DC CMD is always low.
NOTES:-
BOARD 10 (A220) IC's
IC TYPE
1,2,6 and 9 SN15846N
3 SN15836N
4 and 5 SN15862N
7 SN7407N
8 SN158093N
10 SN74121N
STATICISE DELAY
IC10 is triggered by SAMPLE COMMAND when DC and SLOW or AC is selected. Then Q output goes high and holds IC8 Q output (STAT INHIBIT and WAIT) low for 1s. This inhibits staticising allowing the DVM to settle, and lights the WAIT indicator.
The next RANGE COUNT signal after the 1s period clocks IC8 and sets WAIT and STAT INHIBIT high and the reading is staticised.
Selection DC AC Ω
FAST - - -
SLOW + + +
DC FILTER LOGIC
RLA
Selection DC AC Ω
FAST - - -
SLOW + - +
+ = energised
- = unenergised
AC FILTER LOGIC
RLK
Filter DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
OHMS LOGIC
Selection RLF
DC -
AC -
Ω +
+ = energised
- = unenergised
AC AND OHMS LOGIC
RLH RLJ
Range Selection DC AC Ω DC AC Ω
0 1000V (10MΩ) - + + - + +
1 100V (1MΩ) - - - - + +
2 10V (100kΩ) - + + - + +
3 1V (10kΩ) - - - - + +
4 100mV (1kΩ) - + + - - -
DC AND OHMS LOGIC
RLD RLE RLB
Range Selection DC AC Ω DC AC Ω DC AC Ω
0 1000V (10MΩ) + + + - - - + + +
1 100V (1MΩ) - + - - - - + + +
2 10V (100kΩ) + + + + + + + + +
3 1V (10kΩ) - + + + + + + + +
4 100mV (1kΩ) + + - + + - + + +
+ = energised - = unenergised
Inverter
Inverter
PART OF BOARD 10 A220
PART OF BOARD 15 (MOTHER BOARD)
PART OF A204 FAN-OUT
REMOTE RANGE COMMANDS / INFORMATION
RANGE INFORMATION TO DISPLAY (SEE DRG 16)
TO FLOATING SECTION RELAYS (SEE DRG 8)
TO CONTROL LOGIC (SEE DRG. 14)
+5V ALL IC'S PIN 14
0V ALL IC'S PIN 7
NO CONNECTION

RANGE AND MODE LOGIC (A220 AND A223) DESCRIPTION 11

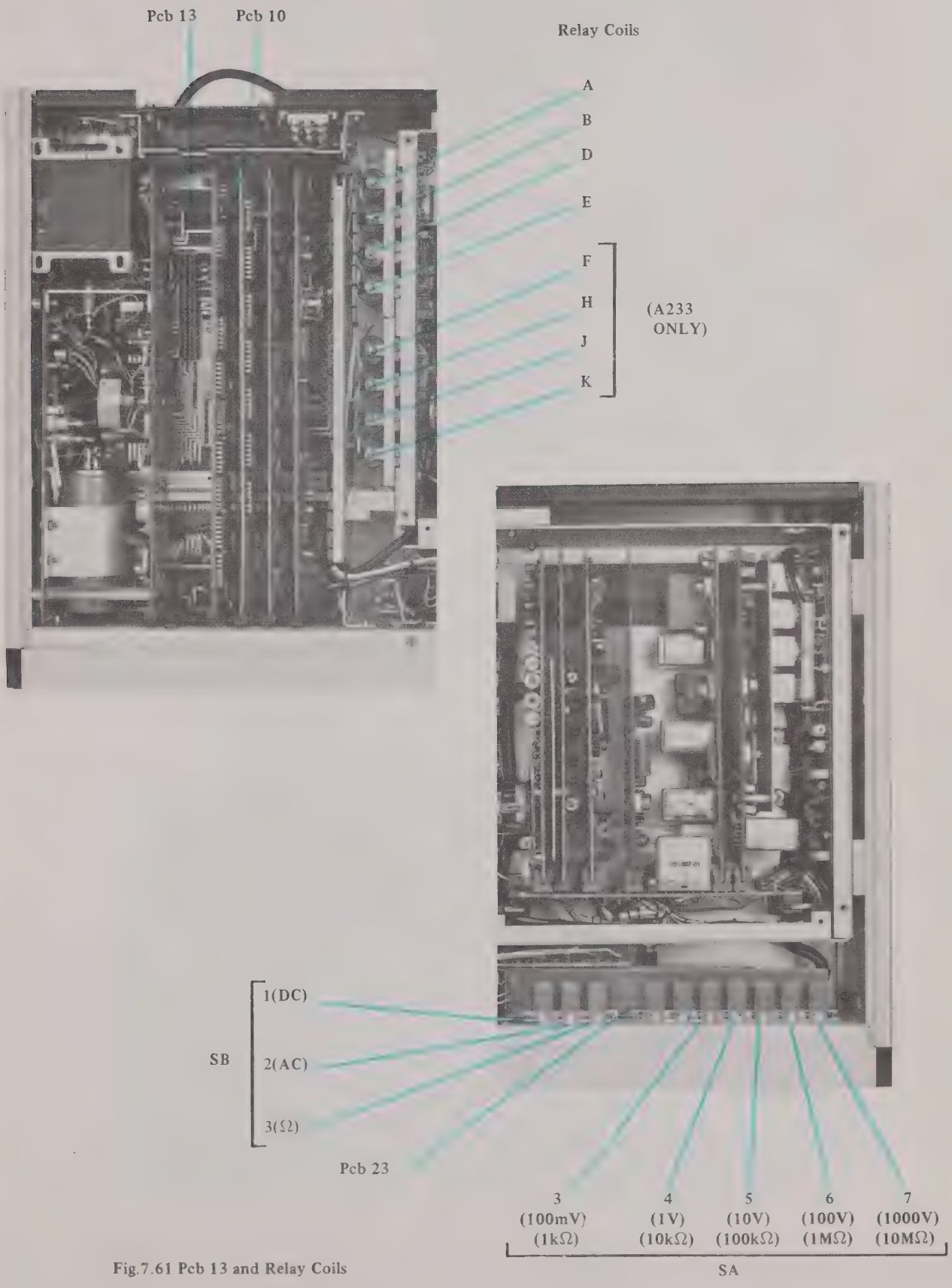


Fig.7.61 Pcb 13 and Relay Coils

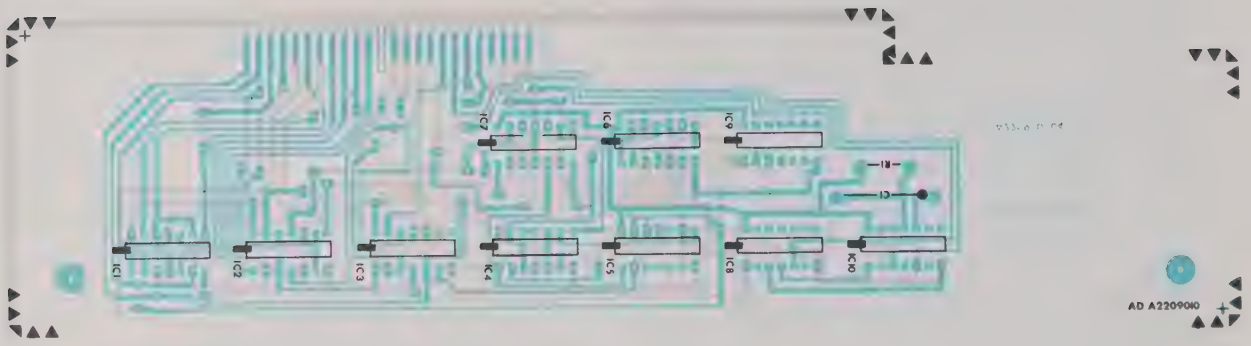
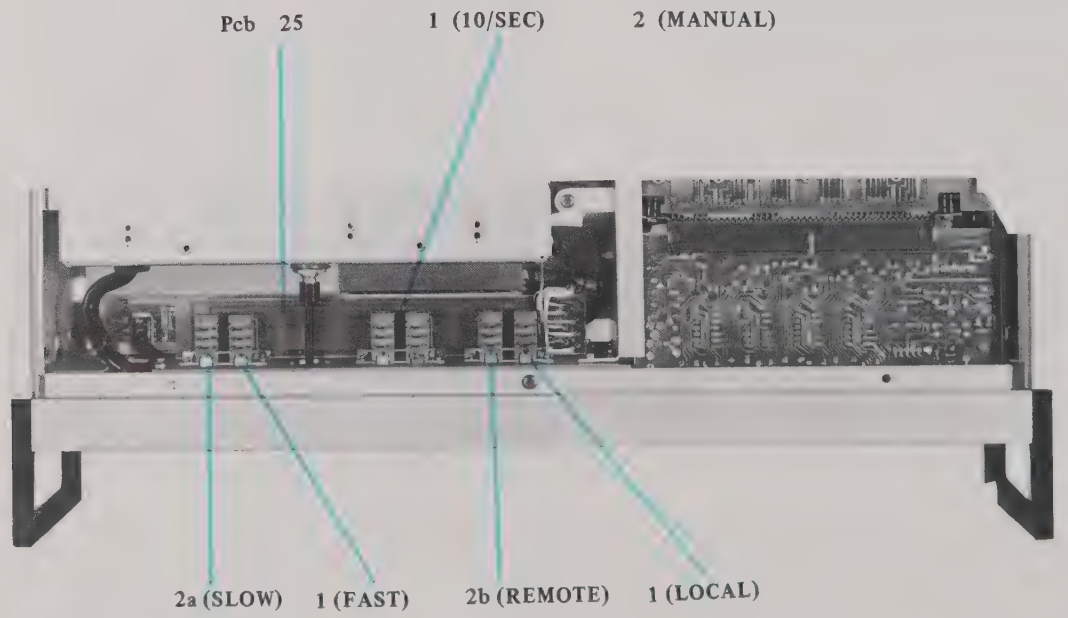


Fig.7.62 Pcb 10 A220, A223

SD



SE SC

Fig.7.64 Pcb 25, SE and SC

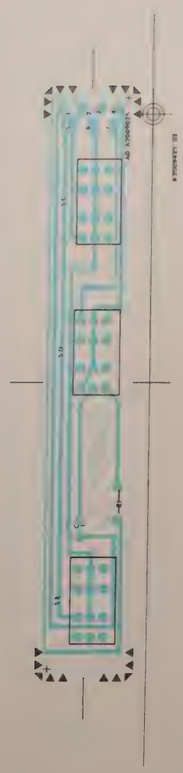
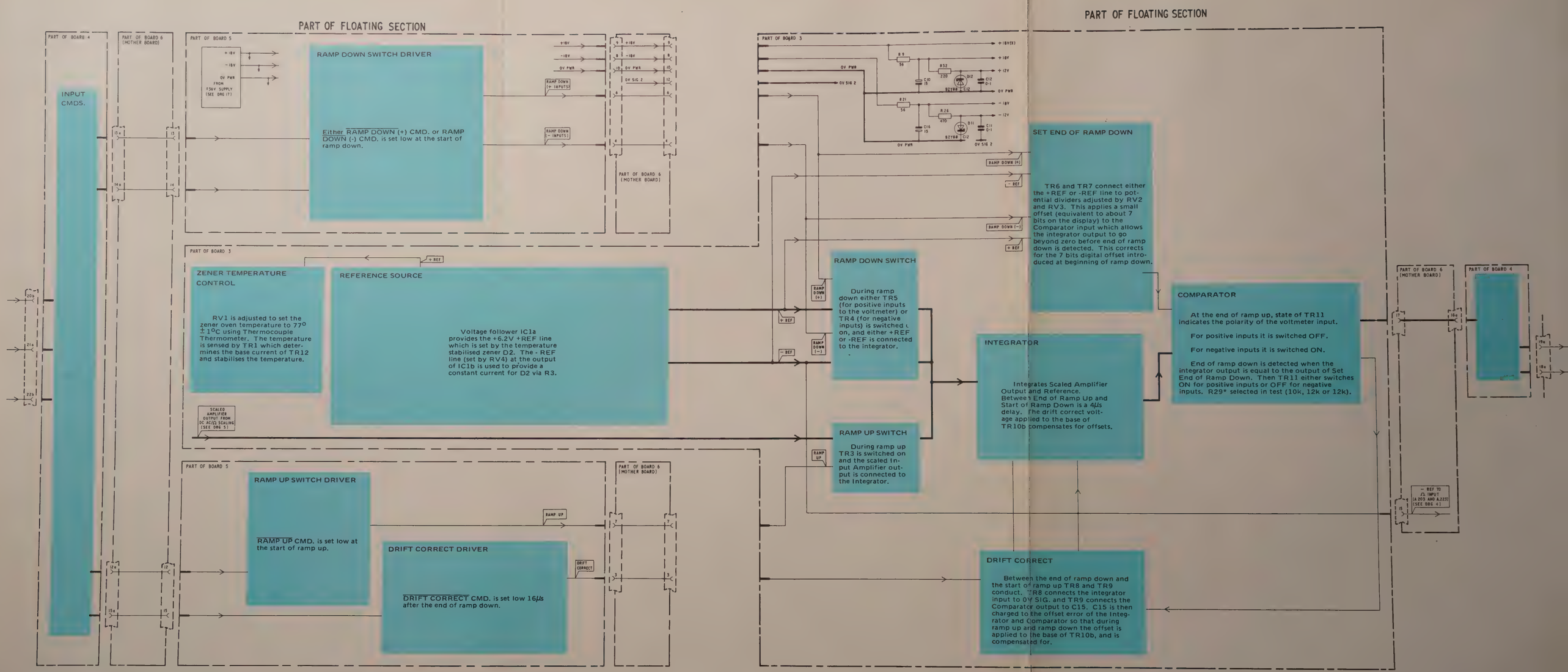


Fig.7.65 Pcb 25

For SD Circuit (10/SEC and MANUAL) see DRG 14 "LOCAL SAMPLE"

RANGE AND MODE LOGIC (A220 AND A223) CIRCUIT 11


PART OF FLOATING SECTION
PART OF FLOATING SECTION
PART OF BOARD 4
INPUT CMDS.
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 5
+18V
-18V
0V PWR FROM +5V SUPPLY (SEE DRG 17)
RAMP DOWN SWITCH DRIVER
Either RAMP DOWN (+) CMD. or RAMP DOWN (-) CMD. is set low at the start of ramp down.
RAMP DOWN (+ INPUTS)
RAMP DOWN (- INPUTS)
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 3
ZENER TEMPERATURE CONTROL
RV1 is adjusted to set the zener oven temperature to 77° ±1°C using Thermocouple Thermometer. The temperature is sensed by TR1 which determines the base current of TR12 and stabilises the temperature.
REFERENCE SOURCE
Voltage follower IC1a provides the +6.2V +REF line which is set by the temperature stabilised zener D2. The - REF line (set by RV4) at the output of IC1b is used to provide a constant current for D2 via R3.
+ REF
SCALED AMPLIFIER OUTPUT FROM DC AC(Δ) SCALING (SEE DRG 5)
PART OF BOARD 5
RAMP UP SWITCH DRIVER
RAMP UP CMD. is set low at the start of ramp up.
RAMP UP
DRIFT CORRECT DRIVER
DRIFT CORRECT CMD. is set low 16μs after the end of ramp down.
DRIFT CORRECT
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 3
+18V(X)
+18V
+12V
0V PWR
0V SIG 2
-18V
-12V
R9 56
R32 220
D12 BZY88 C12
C10 15
C12 0·1
R21 56
R24 470
D11 BZY88 C12
C16 15
C11 0·1
SET END OF RAMP DOWN
TR6 and TR7 connect either the +REF or -REF line to potential dividers adjusted by RV2 and RV3. This applies a small offset (equivalent to about 7 bits on the display) to the Comparator input which allows the integrator output to go beyond zero before end of ramp down is detected. This corrects for the 7 bits digital offset introduced at beginning of ramp down.
RAMP DOWN (+)
- REF
RAMP DOWN (-)
+ REF
RAMP DOWN SWITCH
During ramp down either TR5 (for positive inputs to the voltmeter) or TR4 (for negative inputs) is switched on, and either +REF or -REF is connected to the integrator.
RAMP DOWN (+)
RAMP DOWN (-)
+ REF
- REF
RAMP UP SWITCH
During ramp up TR3 is switched on and the scaled Input Amplifier output is connected to the Integrator.
RAMP UP
INTEGRATOR
Integrates Scaled Amplifier Output and Reference. Between End of Ramp Up and Start of Ramp Down is a 4μs delay. The drift correct voltage applied to the base of TR10b compensates for offsets.
COMPARATOR
At the end of ramp up, state of TR11 indicates the polarity of the voltmeter input.
For positive inputs it is switched OFF.
For negative inputs it is switched ON.
End of ramp down is detected when the integrator output is equal to the output of Set End of Ramp Down. Then TR11 either switches ON for positive inputs or OFF for negative inputs. R29* selected in test (10k, 12k or 12k).
DRIFT CORRECT
Between the end of ramp down and the start of ramp up TR8 and TR9 conduct. TR8 connects the integrator input to 0V SIG. and TR9 connects the Comparator output to C15. C15 is then charged to the offset error of the Integrator and Comparator so that during ramp up and ramp down the offset is applied to the base of TR10b, and is compensated for.
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 4
- REF TO Δ INPUT (A 203 AND A 223) (SEE DRG 4)

INTEGRATOR DESCRIPTION 12

7.12.1

JAB/A200/1

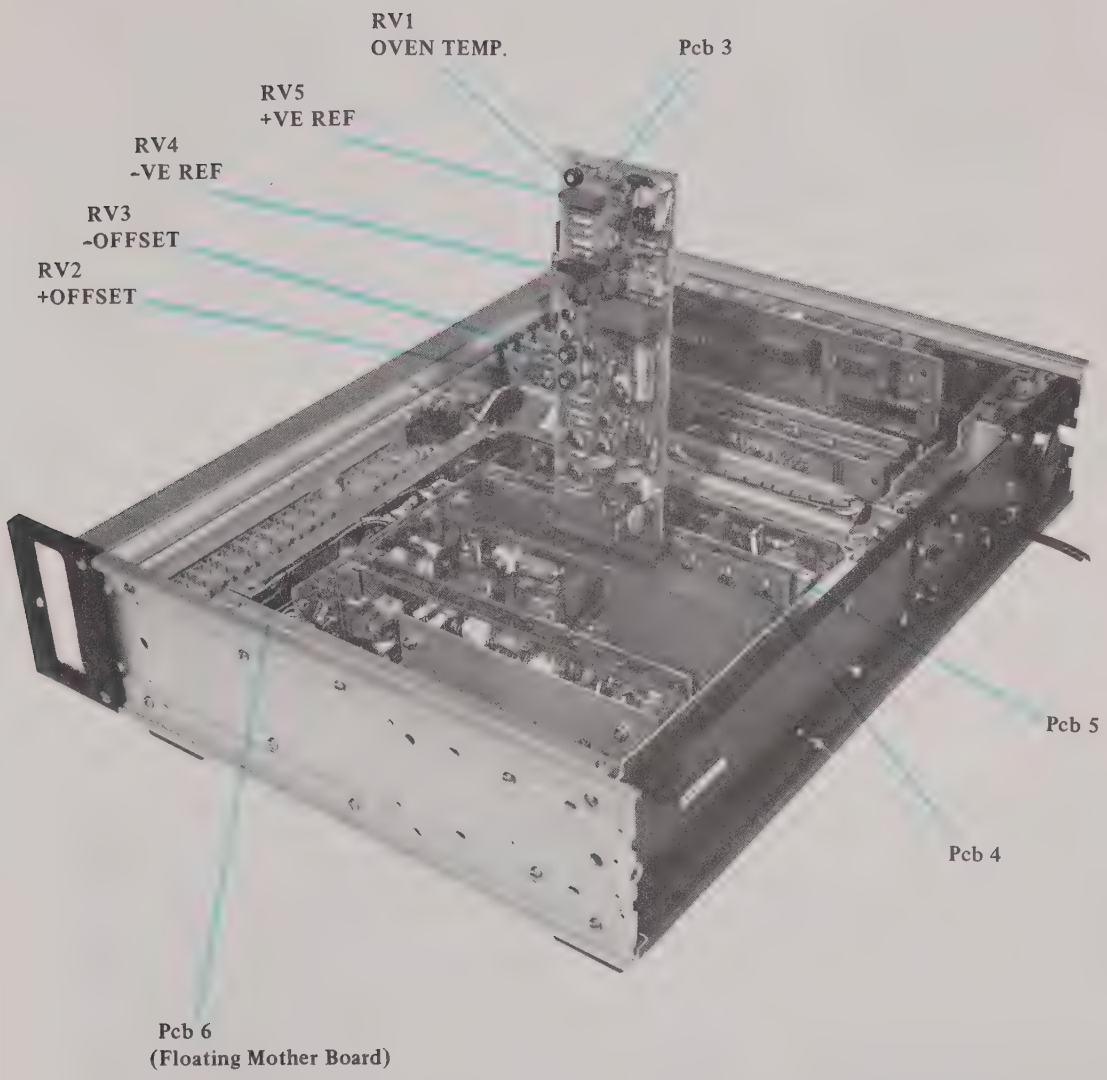


Fig.7.66 Pcb 3 on Extension Board

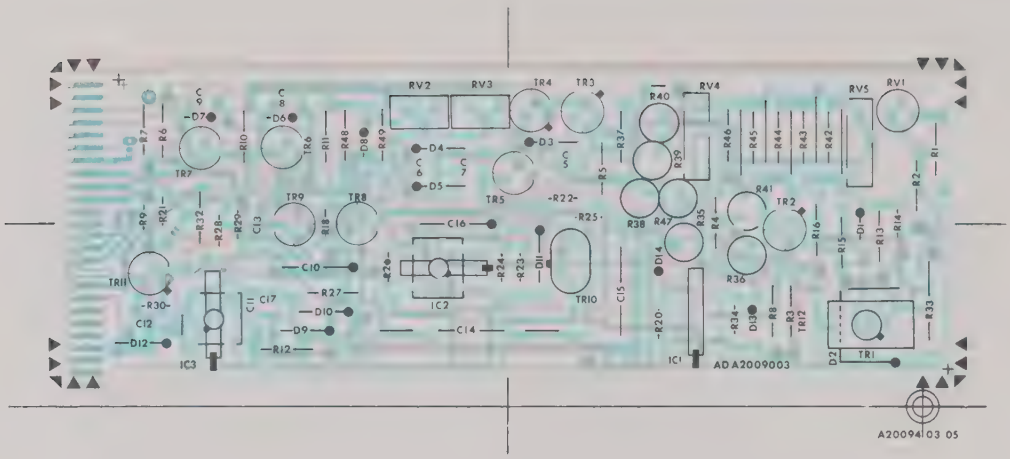


Fig.7.67 Pcb 3

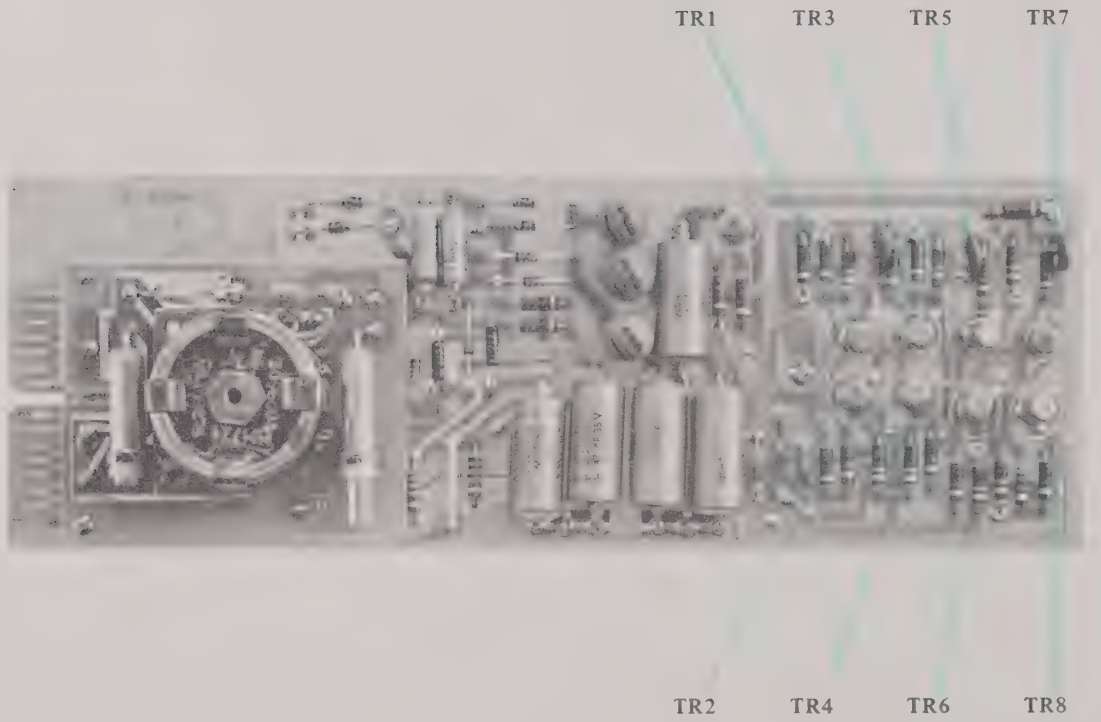
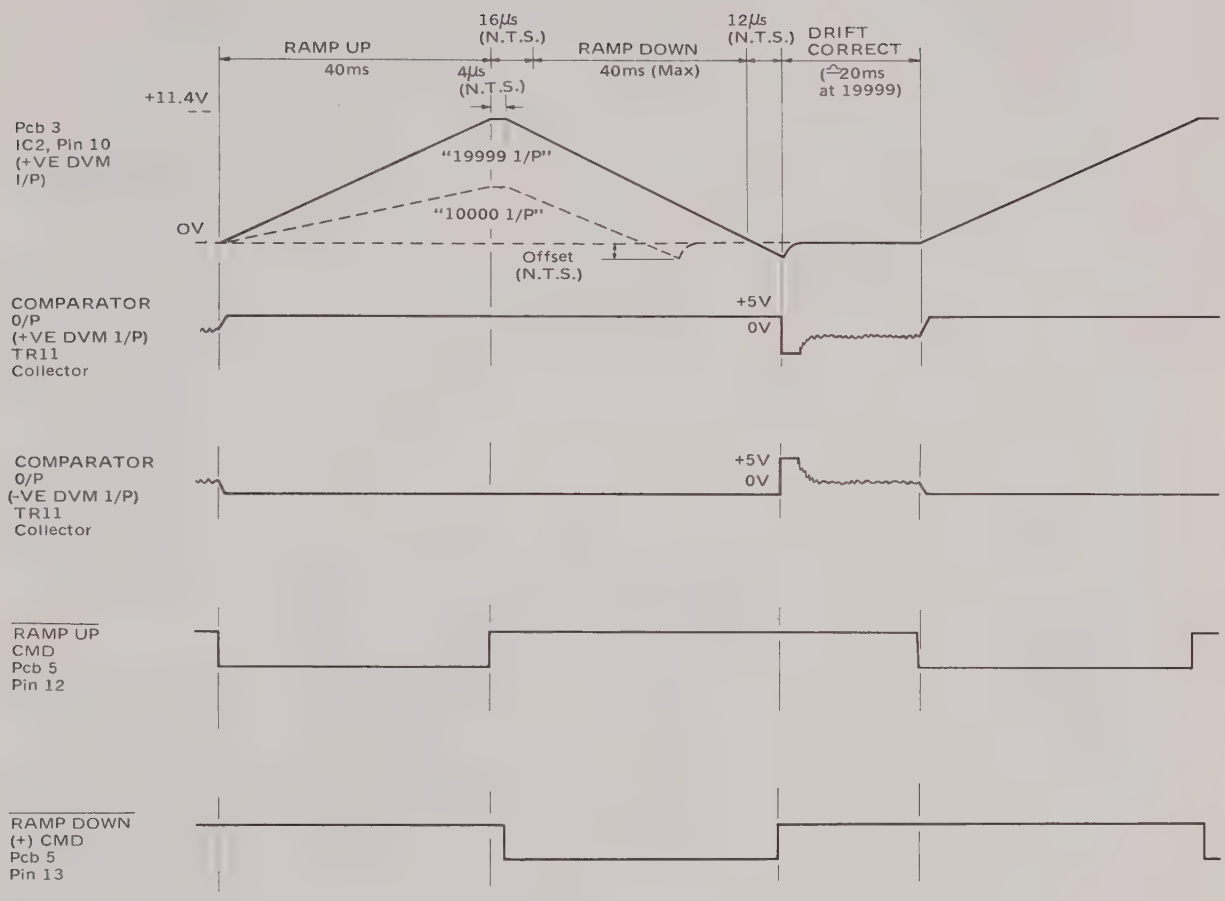


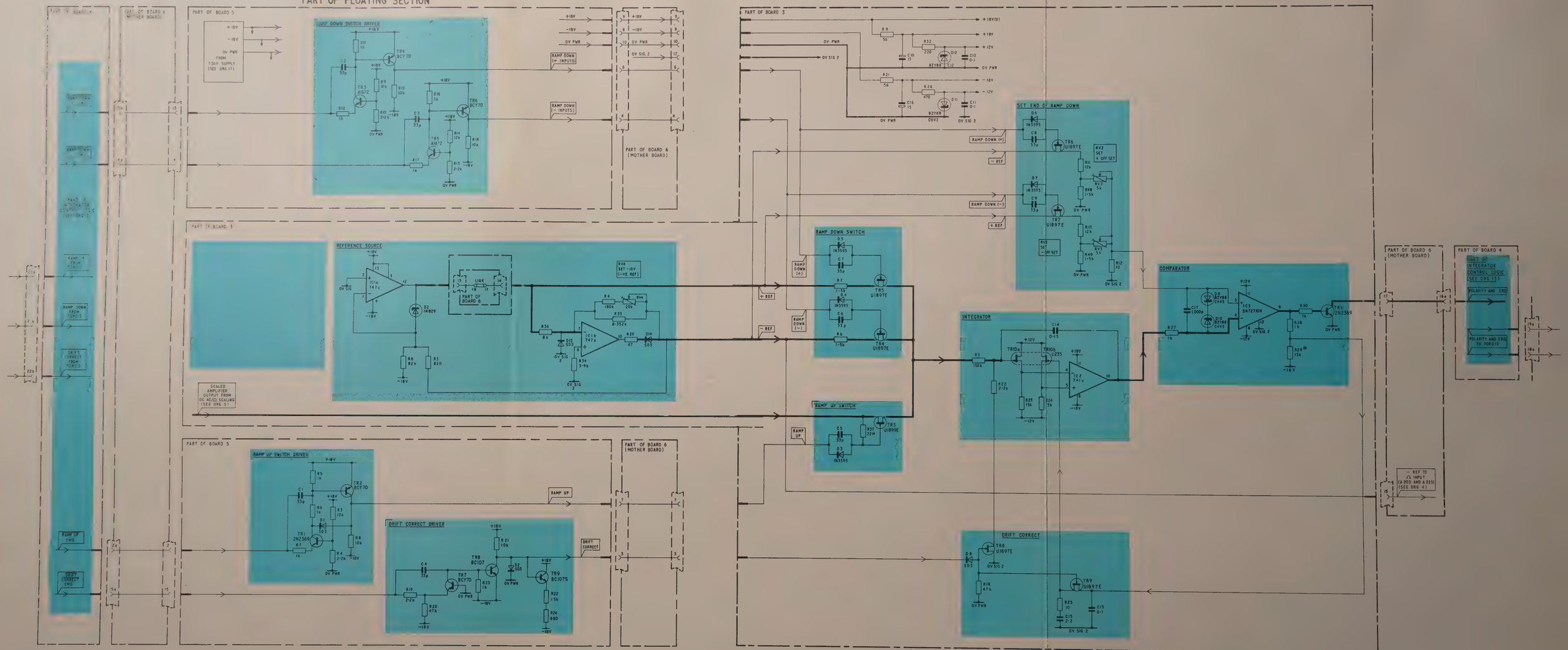
Fig.7.69 Pcb 5, Floating Power Supply and Integrator Switch Drivers.



NOTE: N.T.S. = NOT TO SCALE

Fig.7.70 INTEGRATOR Waveforms

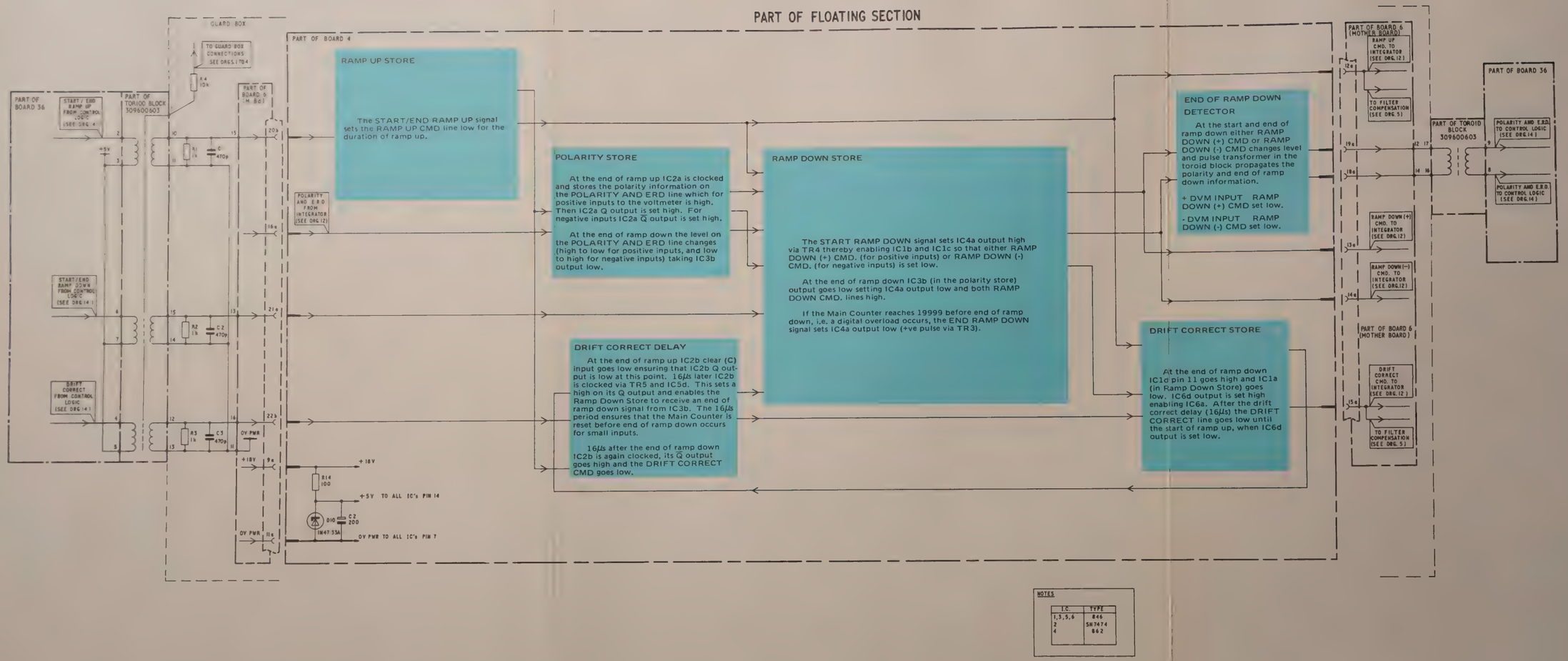
Scaled Amplifier Output (From DRG 5) is 6.4V for a "19999" Dvm Input, and is -VE for a +VE Input.



INTEGRATOR CIRCUIT 12

JR/A200/2

7.12.6


PART OF FLOATING SECTION
GUARD BOX
TO GUARD BOX CONNECTIONS SEE DRGS.1704
PART OF BOARD 4
PART OF BOARD 36
START / END RAMP UP FROM CONTROL LOGIC (SEE DRG 4)
PART OF TOROID BLOCK 309600603
PART OF BOARD 6 (M. BD.)
+5V
R1 1k
C1 470p
POLARITY AND E.R.D FROM INTEGRATOR (SEE DRG.12)
START/END RAMP DOWN FROM CONTROL LOGIC (SEE DRG.14)
R2 1k
C2 470p
DRIFT CORRECT FROM CONTROL LOGIC (SEE DRG 14)
R3 1k
C3 470p
0V PWR
+18V
0V PWR
RAMP UP STORE
The START/END RAMP UP signal sets the RAMP UP CMD line low for the duration of ramp up.
POLARITY STORE
At the end of ramp up IC2a is clocked and stores the polarity information on the POLARITY AND ERD line which for positive inputs to the voltmeter is high. Then IC2a Q output is set high. For negative inputs IC2a Q output is set high.
At the end of ramp down the level on the POLARITY AND ERD line changes (high to low for positive inputs, and low to high for negative inputs) taking IC3b output low.
RAMP DOWN STORE
The START RAMP DOWN signal sets IC4a output high via TR4 thereby enabling IC1b and IC1c so that either RAMP DOWN (+) CMD. (for positive inputs) or RAMP DOWN (-) CMD. (for negative inputs) is set low.
At the end of ramp down IC3b (in the polarity store) output goes low setting IC4a output low and both RAMP DOWN CMD. lines high.
If the Main Counter reaches 19999 before end of ramp down, i.e. a digital overload occurs, the END RAMP DOWN signal sets IC4a output low (+ve pulse via TR3).
DRIFT CORRECT DELAY
At the end of ramp up IC2b clear (C) input goes low ensuring that IC2b Q output is low at this point. 16μs later IC2b is clocked via TR5 and IC5d. This sets a high on its Q output and enables the Ramp Down Store to receive an end of ramp down signal from IC3b. The 16μs period ensures that the Main Counter is reset before end of ramp down occurs for small inputs.
16μs after the end of ramp down IC2b is again clocked, its Q output goes high and the DRIFT CORRECT CMD goes low.
+18V
R14 100
+5V TO ALL IC's PIN 14
D10 IN4733A
C2 200
0V PWR TO ALL IC's PIN 7
END OF RAMP DOWN DETECTOR
At the start and end of ramp down either RAMP DOWN (+) CMD or RAMP DOWN (-) CMD changes level and pulse transformer in the toroid block propagates the polarity and end of ramp down information.
+ DVM INPUT RAMP DOWN (+) CMD set low.
- DVM INPUT RAMP DOWN (-) CMD set low.
DRIFT CORRECT STORE
At the end of ramp down IC1d pin 11 goes high and IC1a (in Ramp Down Store) goes low. IC6d output is set high enabling IC6a. After the drift correct delay (16μs) the DRIFT CORRECT line goes low until the start of ramp up, when IC6d output is set low.
PART OF BOARD 6 (MOTHER BOARD)
RAMP UP CMD. TO INTEGRATOR (SEE DRG.12)
TO FILTER COMPENSATION (SEE DRG.5)
PART OF TOROID BLOCK 309600603
PART OF BOARD 36
POLARITY AND E.R.D. TO CONTROL LOGIC (SEE DRG.14)
RAMP DOWN (+) CMD. TO INTEGRATOR (SEE DRG.12)
RAMP DOWN (-) CMD. TO INTEGRATOR (SEE DRG.12)
PART OF BOARD 6 (MOTHER BOARD)
DRIFT CORRECT CMD. TO INTEGRATOR (SEE DRG.12)
TO FILTER COMPENSATION (SEE DRG. 5)
NOTES
I.C. TYPE
1,3,5,6 846
2 SN7474
4 862

INTEGRATOR CONTROL LOGIC DESCRIPTION 13

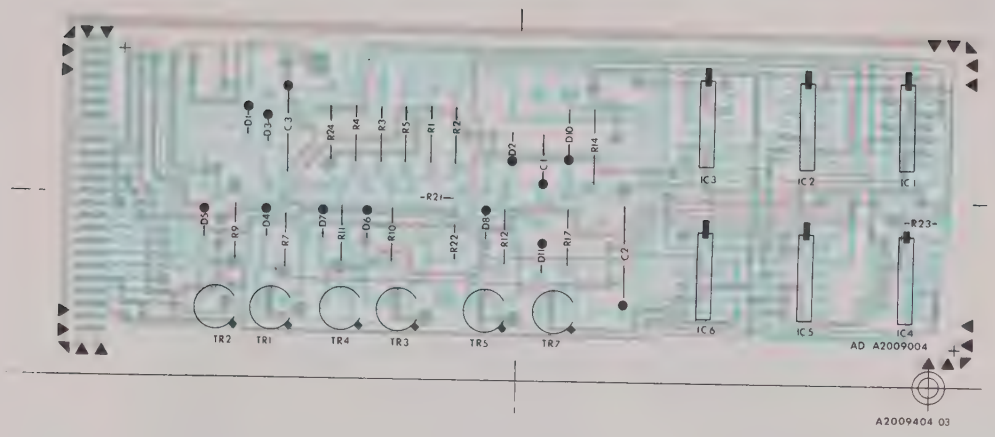


Fig.7.71 Pcb 4

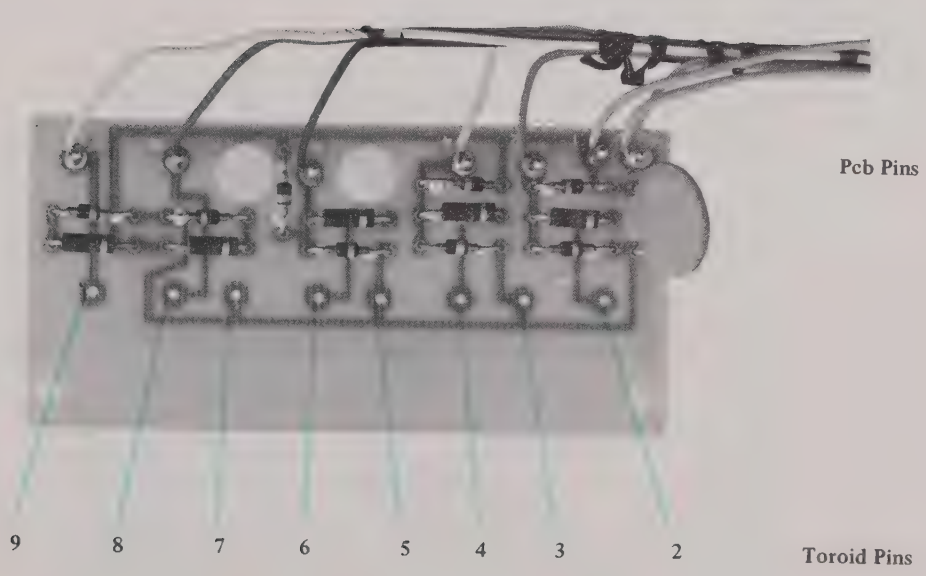
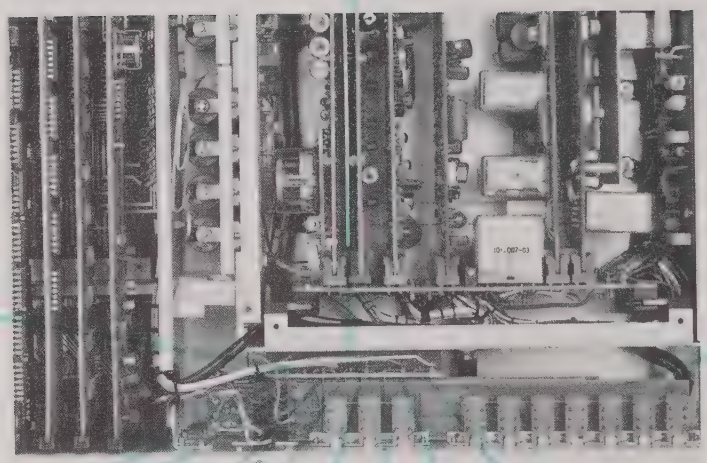


Fig.7.73 Pcb 36 Toroid Pin Connections, Earthy Side

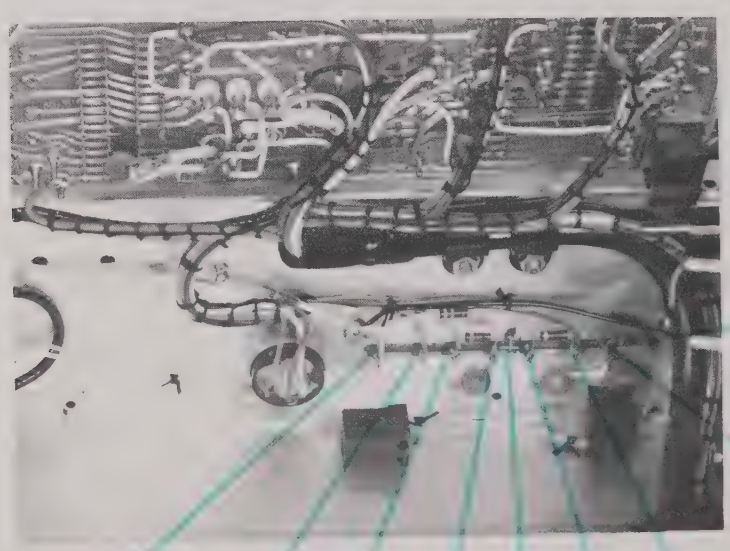


Pcb 36

Pcb 23

Pins 2 3 4 5 6 7 8 9
(Concealed)

Fig.7.74 Toroid Block Pins, Earthy Side.

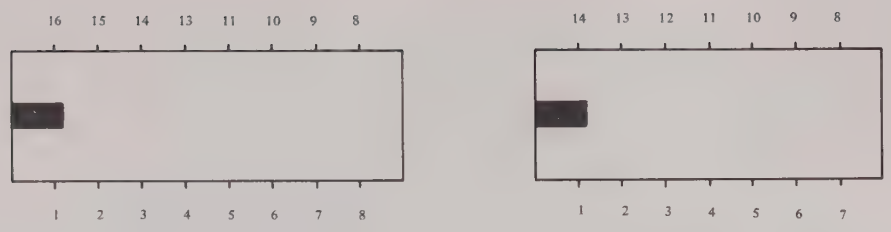


10

11

Pins 17 16 15 14 1 13 12

Fig.7.75 Toroid Block Pins, Floating Side



Dual-in-Line IC Pins (Top View)

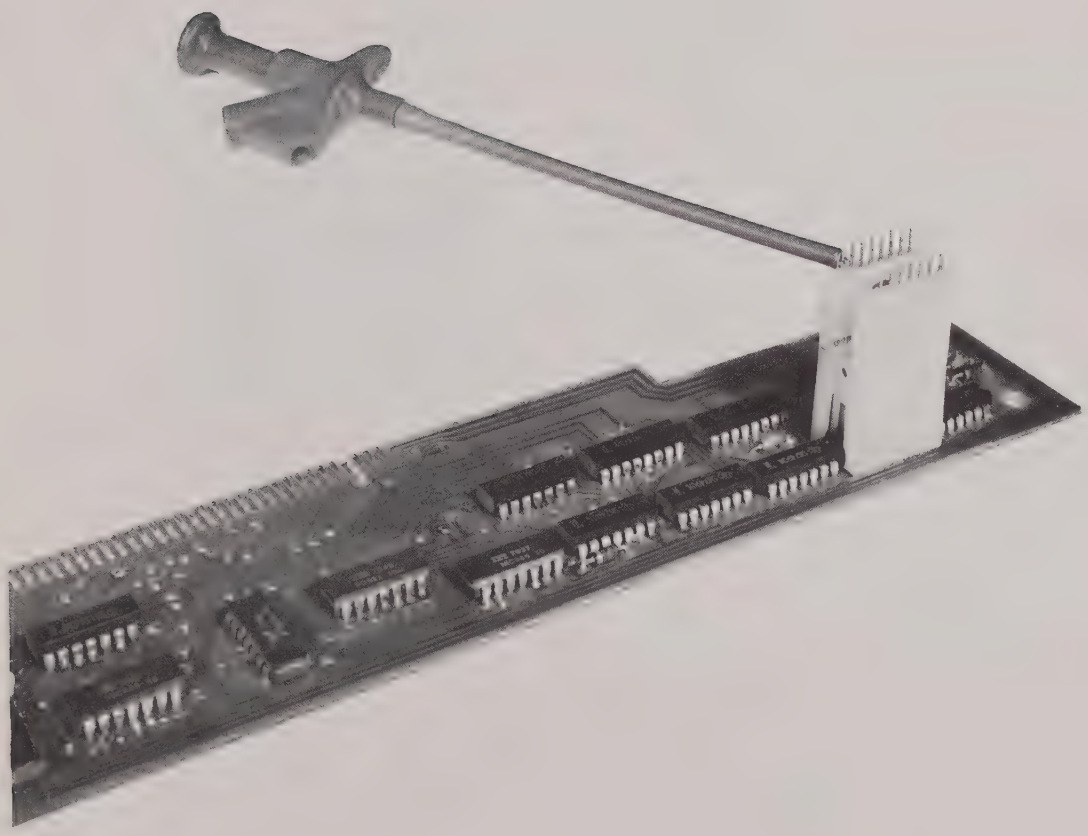


Fig.7.76 Using an IC Pin Clip

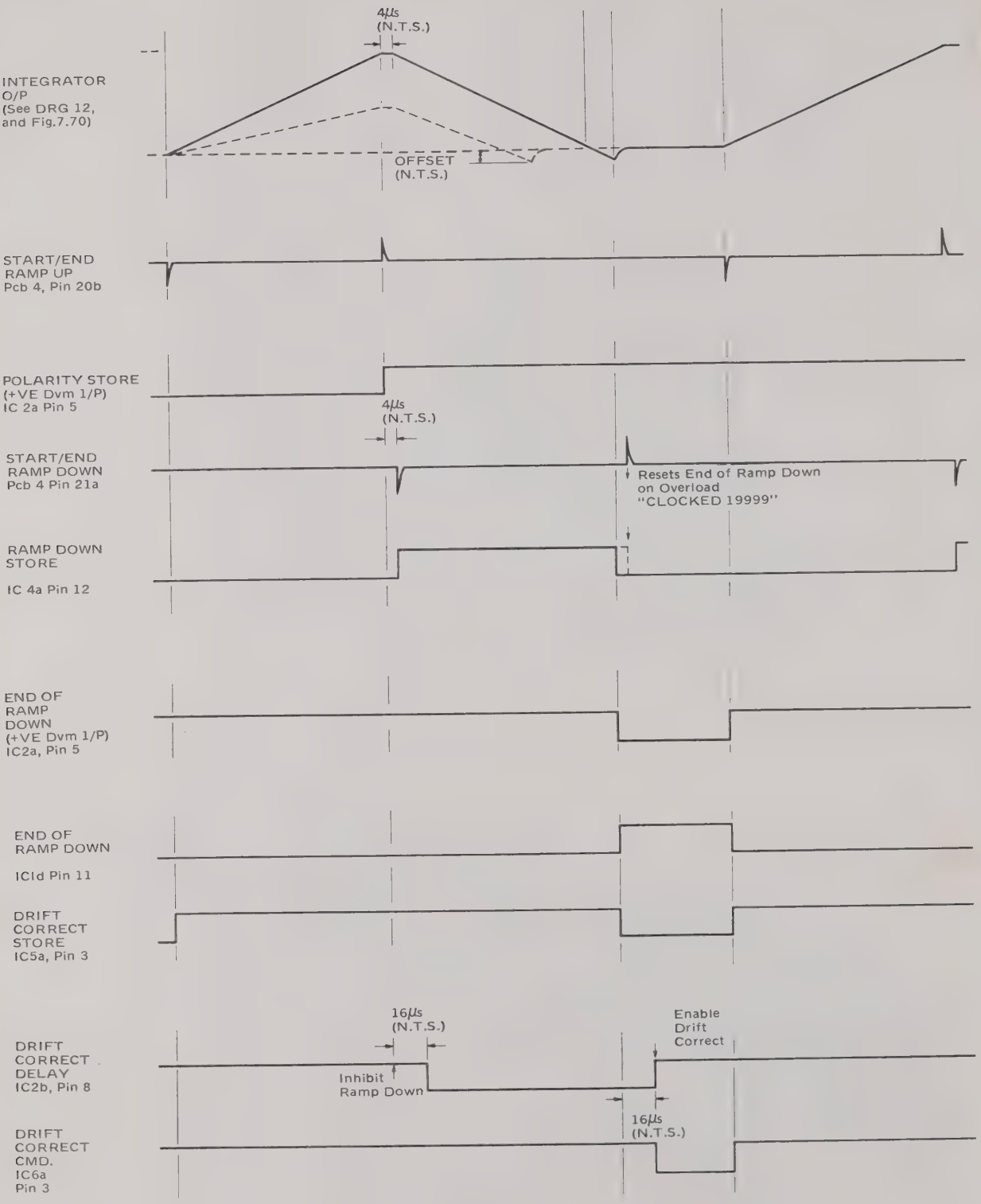
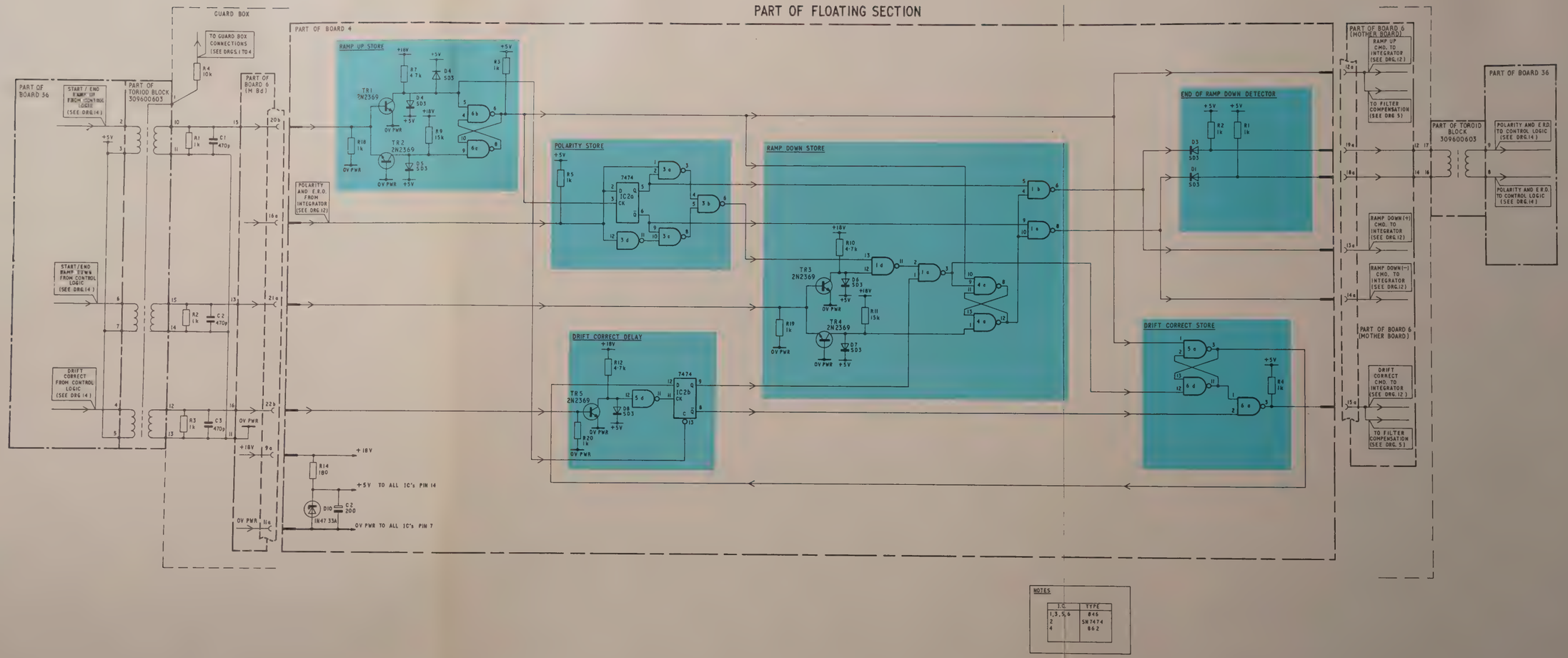
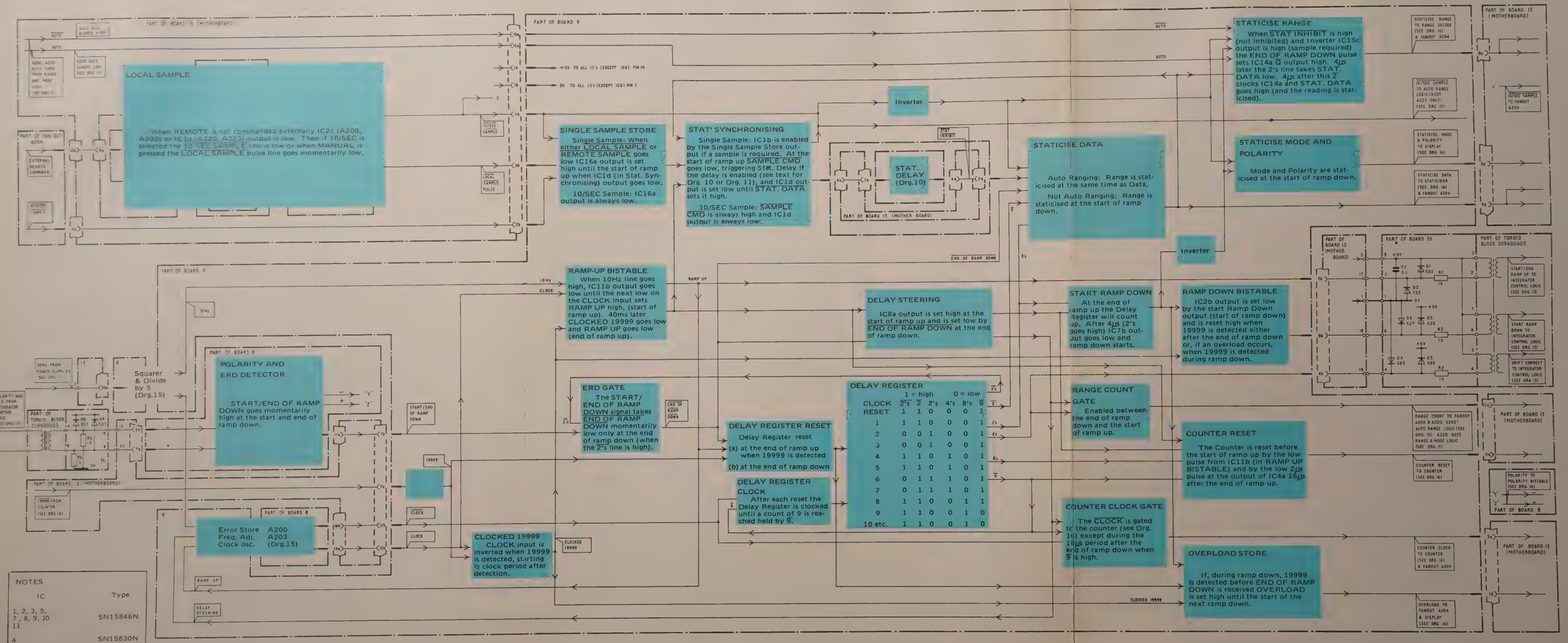


Fig.7.77 INTEGRATOR CONTROL Waveforms


PART OF FLOATING SECTION
GUARD BOX
TO GUARD BOX CONNECTIONS (SEE DRGS. 1 TO 4)
PART OF BOARD 4
PART OF BOARD 36
START / END RAMP TIMES FROM CONTROL LOGIC (SEE DRG. 14)
PART OF TOROID BLOCK 30960603
PART OF BOARD 6 (M Bd)
RAMP UP STORE
POLARITY STORE
RAMP DOWN STORE
END OF RAMP DOWN DETECTOR
DRIFT CORRECT DELAY
DRIFT CORRECT STORE
POLARITY AND E.R.D. FROM INTEGRATOR (SEE DRG. 12)
START/END RAMP TIMES FROM CONTROL LOGIC (SEE DRG. 14)
DRIFT CORRECT FROM CONTROL LOGIC (SEE DRG. 14)
+5V TO ALL IC's PIN 14
0V PWR TO ALL IC's PIN 7
PART OF BOARD 6 (MOTHER BOARD)
RAMP UP CMD. TO INTEGRATOR (SEE DRG. 12)
TO FILTER COMPENSATION (SEE DRG 5)
RAMP DOWN (+) CMD. TO INTEGRATOR (SEE DRG. 12)
RAMP DOWN (−) CMD. TO INTEGRATOR (SEE DRG. 12)
DRIFT CORRECT CMD. TO INTEGRATOR (SEE DRG. 12)
POLARITY AND E.R.D. TO CONTROL LOGIC (SEE DRG. 14)
NOTES
I.C. TYPE
1, 3, 5, 6 846
2 SN7474
4 862

INTEGRATOR CONTROL LOGIC CIRCUIT 13


LOCAL SAMPLE
When REMOTE is not commanded externally IC2c (A200, A203) or IC3d (A220, A223) output is low. Then if 10/SEC is selected the 10 SEC SAMPLE line is low or when MANUAL is pressed the LOCAL SAMPLE pulse line goes momentarily low.
SINGLE SAMPLE STORE
Single Sample: When either LOCAL SAMPLE or REMOTE SAMPLE goes low IC16a output is set high until the start of ramp up when IC1d (in Stat. Synchronising) output goes low.
10/SEC Sample: IC16a output is always low.
STAT' SYNCHRONISING
Single Sample: IC1b is enabled by the Single Sample Store output if a sample is required. At the start of ramp up SAMPLE CMD goes low, triggering Stat. Delay if the delay is enabled (see text for Drg. 10 or Drg. 11), and IC1d output is set low until STAT. DATA sets it high.
10/SEC Sample: SAMPLE CMD is always high and IC1d output is always low.
Inverter
STAT. DELAY (Drg.10)
STATICISE DATA
Auto Ranging: Range is staticised at the same time as Data.
Not Auto Ranging: Range is staticised at the start of ramp down.
STATICISE RANGE
When STAT INHIBIT is high (not inhibited) and inverter IC15c output is high (sample required) the END OF RAMP DOWN pulse sets IC14a Q output high. 4μs later the 2's line takes STAT. DATA low. 4μs after this 2̄ clocks IC14a and STAT. DATA goes high (and the reading is staticised).
STATICISE MODE AND POLARITY
Mode and Polarity are staticised at the start of ramp down.
RAMP-UP BISTABLE
When 10Hz line goes high, IC11b output goes low until the next low on the CLOCK input sets RAMP UP high, (start of ramp up). 40ms later CLOCKED 19999 goes low and RAMP UP goes low (end of ramp up).
DELAY STEERING
IC8a output is set high at the start of ramp up and is set low by END OF RAMP DOWN at the end of ramp down.
START RAMP DOWN
At the end of ramp up the Delay Register will count up. After 4μs (2's goes high) IC7b output goes low and ramp down starts.
RAMP DOWN BISTABLE
IC2b output is set low by the start Ramp Down output (start of ramp down) and is reset high when 19999 is detected either after the end of ramp down or, if an overload occurs, when 19999 is detected during ramp down.
POLARITY AND ERD DETECTOR
START/END OF RAMP DOWN goes momentarily high at the start and end of ramp down.
Squarer & Divide by 5 (Drg.15)
ERD GATE
The START/END OF RAMP DOWN signal takes END OF RAMP DOWN momentarily low only at the end of ramp down (when the 2's line is high).
DELAY REGISTER RESET
Delay Register reset
(a) at the end of ramp up when 19999 is detected
(b) at the end of ramp down
DELAY REGISTER CLOCK
After each reset the Delay Register is clocked until a count of 9 is reached held by 9̄.
DELAY REGISTER
1 = high 0 = low
CLOCK RESET 2's 2̄ 2's 4's 8's 9̄
1 1 1 0 0 0 1
2 0 0 1 0 0 1
3 0 0 1 0 0 1
4 1 1 0 1 0 1
5 1 1 0 1 0 1
6 0 1 1 1 0 1
7 0 1 1 1 0 1
8 1 1 0 0 1 1
9 1 1 0 0 1 0
10 etc. 1 1 0 0 1 0
RANGE COUNT GATE
Enabled between the end of ramp down and the start of ramp up.
COUNTER RESET
The Counter is reset before the start of ramp up by the low pulse from IC11b (in RAMP UP BISTABLE) and by the low 2μs pulse at the output of IC4a 16μs after the end of ramp up.
COUNTER CLOCK GATE
The CLOCK is gated to the counter (see Drg. 16) except during the 18μs period after the end of ramp down when 9 is high.
OVERLOAD STORE
If, during ramp down, 19999 is detected before END OF RAMP DOWN is received OVERLOAD is set high until the start of the next ramp down.
CLOCKED 19999
CLOCK input is inverted when 19999 is detected, starting ½ clock period after detection.
Error Store A200
Freq. Adj. A203
Clock osc. (Drg.15)
NOTES
IC Type
1, 2, 3, 5, 7, 8, 9, 10, 11 SN15846N
4 SN15830N
6 SN7490N
12, 13 SN158093N
14 SN7474
15 SN15836N
16 SN15862N

CONTROL LOGIC DESCRIPTION 14

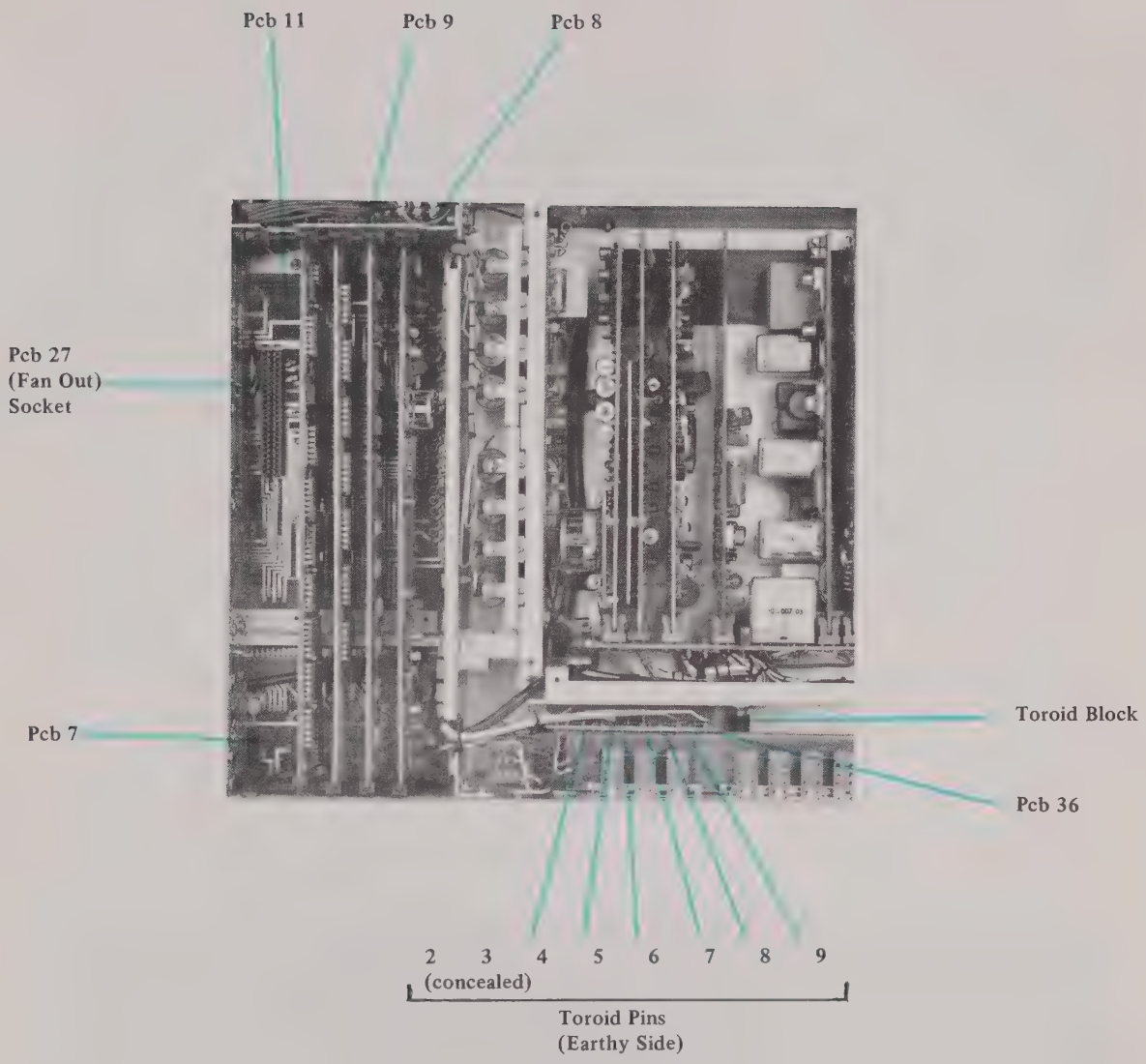


Fig.7.78 Pcb 36 and Toroid Block Location

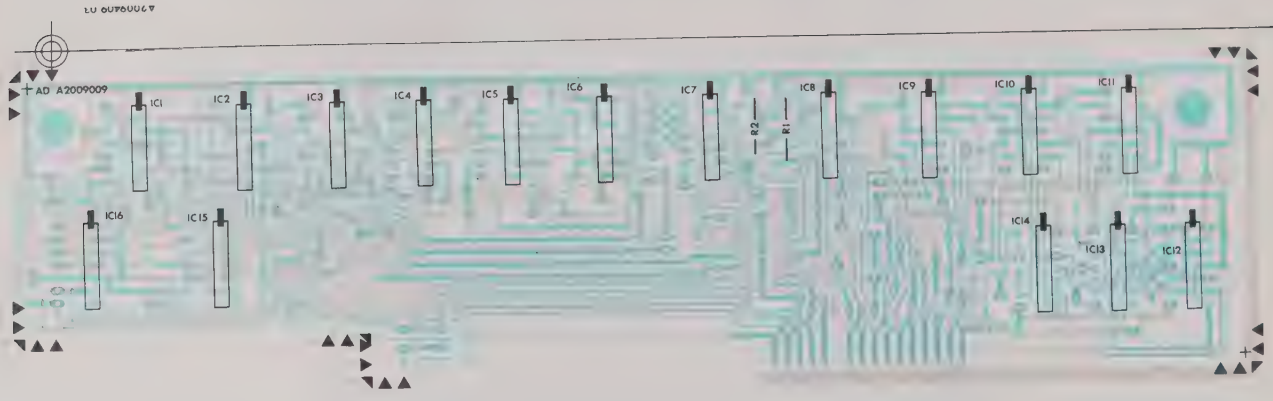


Fig.7.79 Pcb 9

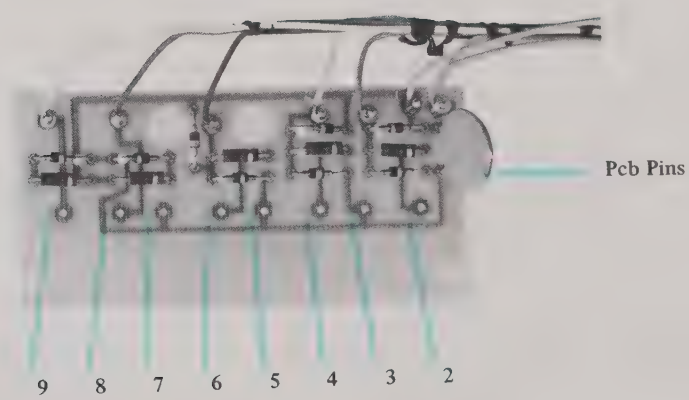
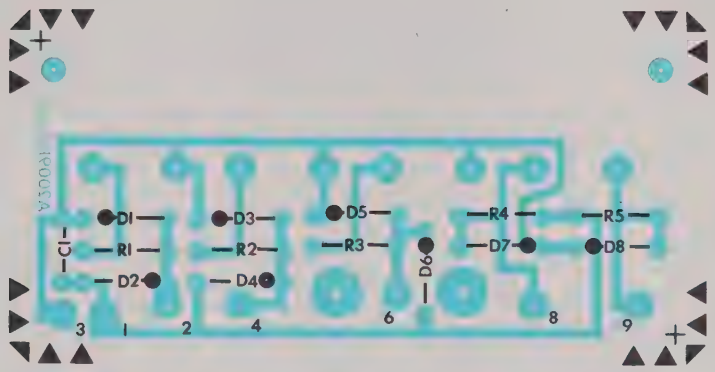


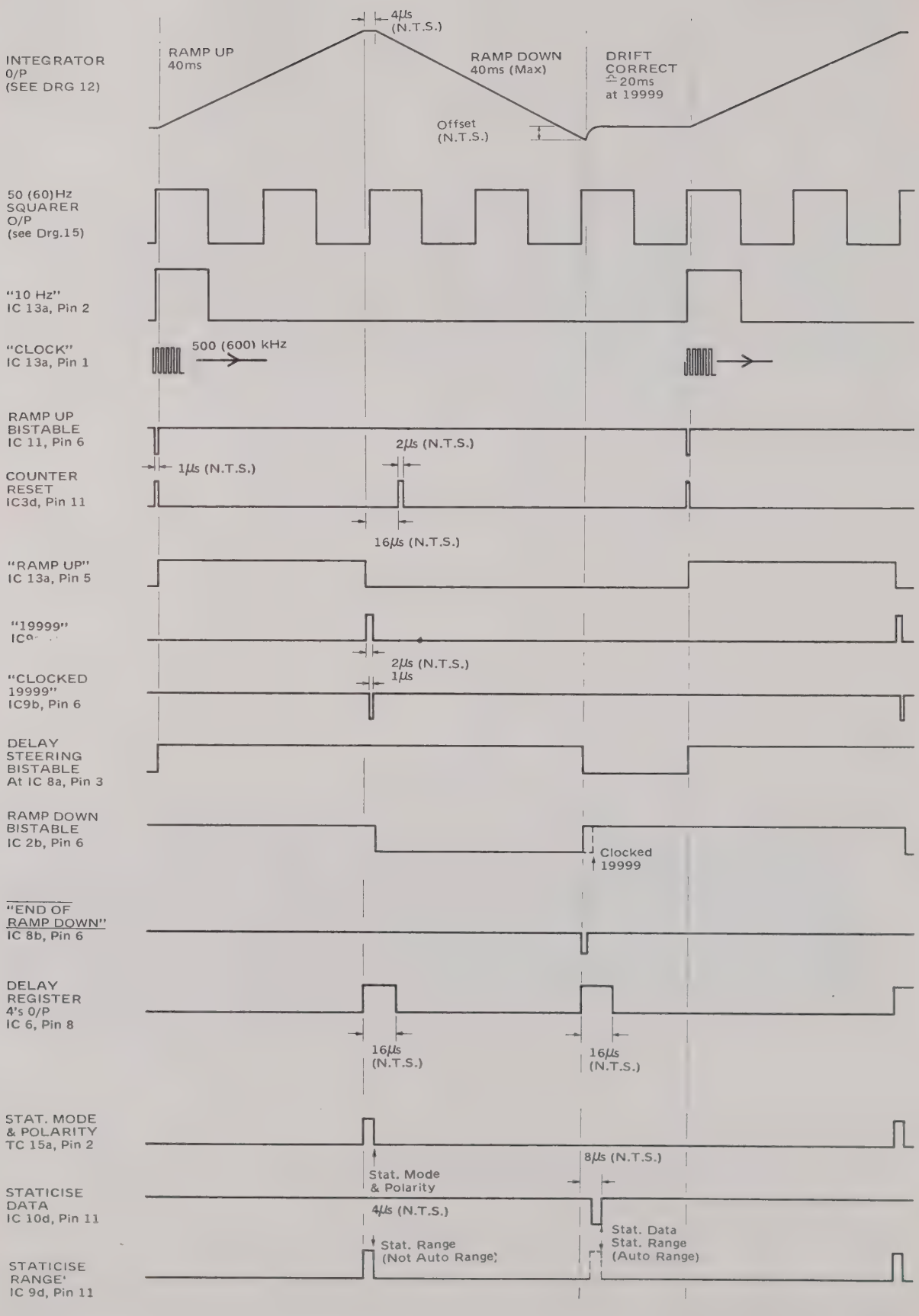
Fig.7.81 Pcb 36 Toroid Pin Connections, Earthy Side (Shown as fitted)



A2009436 02

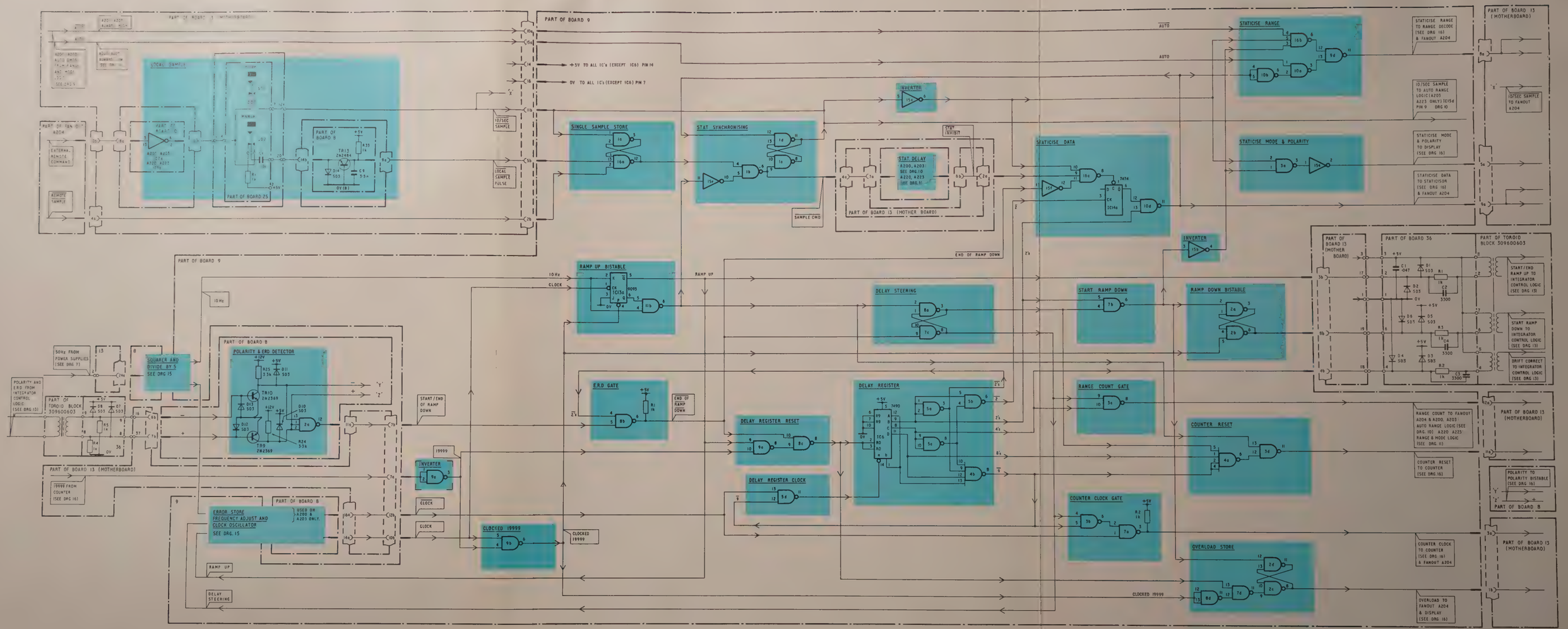
Fig.7.82 Pcb 36

Fig.7.84 Pcb 8 A200, A203. TR9, TR10 and IC2

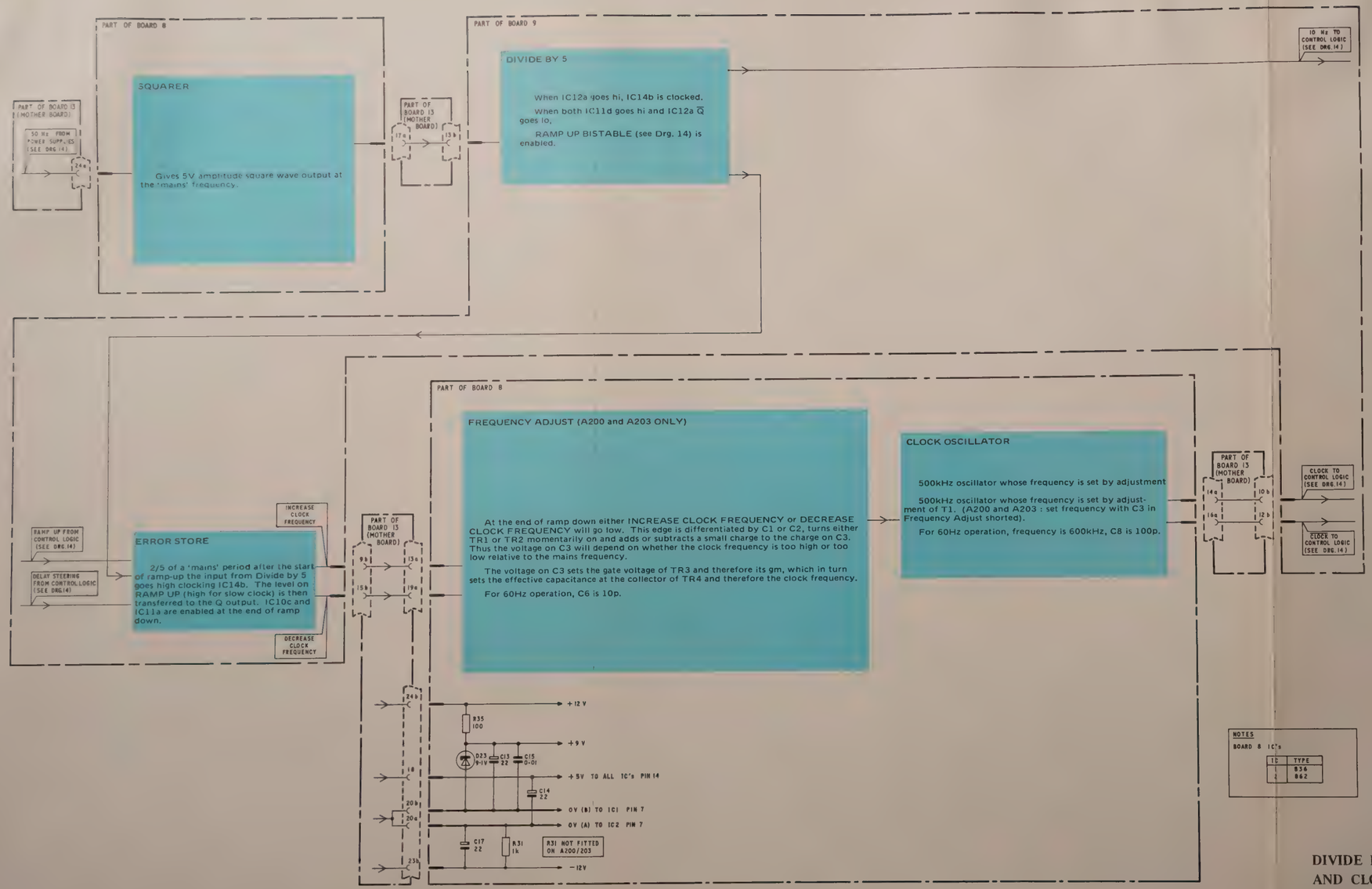

INTEGRATOR O/P (SEE DRG 12)
4μs (N.T.S.)
RAMP UP 40ms
RAMP DOWN 40ms (Max)
DRIFT CORRECT ≙20ms at 19999
Offset (N.T.S.)
50 (60)Hz SQUARER O/P (see Drg.15)
"10 Hz" IC 13a, Pin 2
"CLOCK" IC 13a, Pin 1
500 (600) kHz
RAMP UP BISTABLE IC 11, Pin 6
2μs (N.T.S.)
1μs (N.T.S.)
COUNTER RESET IC3d, Pin 11
16μs (N.T.S.)
"RAMP UP" IC 13a, Pin 5
"19999" IC
2μs (N.T.S.)
1μs
"CLOCKED 19999" IC9b, Pin 6
DELAY STEERING BISTABLE At IC 8a, Pin 3
RAMP DOWN BISTABLE IC 2b, Pin 6
Clocked 19999
"END OF RAMP DOWN" IC 8b, Pin 6
DELAY REGISTER 4's O/P IC 6, Pin 8
16μs (N.T.S.)
16μs (N.T.S.)
STAT. MODE & POLARITY TC 15a, Pin 2
8μs (N.T.S.)
Stat. Mode & Polarity
STATICISE DATA IC 10d, Pin 11
4μs (N.T.S.)
Stat. Range (Not Auto Range)
Stat. Data
Stat. Range (Auto Range)
STATICISE RANGE' IC 9d, Pin 11

Note: N.T.S. = NOT TO SCALE

Fig.7.85 CONTROL LOGIC WAVEFORMS


PART OF BOARD 9
+5V TO ALL IC's (EXCEPT IC6) PIN 14
0V TO ALL IC's (EXCEPT IC6) PIN 7
LOCAL SAMPLE
10/SEC SAMPLE
LOCAL SAMPLE PULSE
PART OF BOARD 25
SINGLE SAMPLE STORE
STAT SYNCHRONISING
INVERTER
STAT DELAY
A200, A203: SEE DRG.10
A220, A223 SEE DRG.11
SAMPLE CMD
PART OF BOARD 13 (MOTHER BOARD)
STATICISE DATA
STATICISE RANGE
STATICISE MODE & POLARITY
AUTO
STATICISE RANGE TO RANGE DECODE (SEE DRG 16) & FANOUT A204
10/SEC SAMPLE TO AUTO RANGE LOGIC (A203 A223 ONLY) IC15d PIN 9 DRG 10
STATICISE MODE & POLARITY TO DISPLAY (SEE DRG 16)
STATICISE DATA TO STATICISOR (SEE DRG 16) & FANOUT A204
PART OF BOARD 13 (MOTHERBOARD)
PART OF BOARD 9
10 Hz
RAMP UP BISTABLE
CLOCK
RAMP UP
END OF RAMP DOWN
DELAY STEERING
START RAMP DOWN
RAMP DOWN BISTABLE
PART OF BOARD 36
PART OF TOROID BLOCK 309600603
START/END RAMP UP TO INTEGRATOR CONTROL LOGIC (SEE DRG 15)
START RAMP DOWN TO INTEGRATOR CONTROL LOGIC (SEE DRG 15)
DRIFT CORRECT TO INTEGRATOR CONTROL LOGIC (SEE DRG 15)
50Hz FROM POWER SUPPLIES (SEE DRG 7)
SQUARER AND DIVIDE BY 5 SEE DRG 15
PART OF BOARD 8
POLARITY & ERD DETECTOR
TRIO 2N2369
TR9 2N2369
POLARITY AND E.R.D. FROM INTEGRATOR CONTROL LOGIC (SEE DRG 13)
PART OF TOROID BLOCK 309600603
E.R.D GATE
END OF RAMP DOWN
DELAY REGISTER
DELAY REGISTER RESET
DELAY REGISTER CLOCK
RANGE COUNT GATE
COUNTER RESET
RANGE COUNT TO FANOUT A204 & A200, A203: AUTO RANGE LOGIC (SEE DRG. 10) A220, A223: RANGE & MODE LOGIC (SEE DRG. 11)
COUNTER RESET TO COUNTER (SEE DRG. 16)
POLARITY TO POLARITY BISTABLE (SEE DRG. 16)
PART OF BOARD 13 (MOTHERBOARD)
PART OF BOARD 13 (MOTHERBOARD)
PART OF BOARD 8
19999
INVERTER
START/END OF RAMP DOWN
CLOCK
CLOCK
PART OF BOARD 13 (MOTHERBOARD)
19999 FROM COUNTER (SEE DRG 16)
ERROR STORE FREQUENCY ADJUST AND CLOCK OSCILLATOR SEE DRG. 15
USED ON A200 & A203 ONLY.
CLOCKED 19999
COUNTER CLOCK GATE
OVERLOAD STORE
COUNTER CLOCK TO COUNTER (SEE DRG 16) & FANOUT A204
OVERLOAD TO FANOUT A204 & DISPLAY (SEE DRG 16)
RAMP UP
DELAY STEERING

CONTROL LOGIC CIRCUIT 14


PART OF BOARD 8
PART OF BOARD 13 (MOTHER BOARD)
50 Hz FROM POWER SUPPLIES (SEE DRG 14)
24a
SQUARER
Gives 5V amplitude square wave output at the 'mains' frequency.
PART OF BOARD 13 (MOTHER BOARD)
17a
12b
PART OF BOARD 9
DIVIDE BY 5
When IC12a goes hi, IC14b is clocked.
When both IC11d goes hi and IC12a Q goes lo,
RAMP UP BISTABLE (see Drg. 14) is enabled.
10 Hz TO CONTROL LOGIC (SEE DRG.14)
PART OF BOARD 8
FREQUENCY ADJUST (A200 and A203 ONLY)
At the end of ramp down either INCREASE CLOCK FREQUENCY or DECREASE CLOCK FREQUENCY will go low. This edge is differentiated by C1 or C2, turns either TR1 or TR2 momentarily on and adds or subtracts a small charge to the charge on C3. Thus the voltage on C3 will depend on whether the clock frequency is too high or too low relative to the mains frequency.
The voltage on C3 sets the gate voltage of TR3 and therefore its gm, which in turn sets the effective capacitance at the collector of TR4 and therefore the clock frequency.
For 60Hz operation, C6 is 10p.
CLOCK OSCILLATOR
500kHz oscillator whose frequency is set by adjustment
500kHz oscillator whose frequency is set by adjustment of T1. (A200 and A203 : set frequency with C3 in Frequency Adjust shorted).
For 60Hz operation, frequency is 600kHz, C8 is 100p.
PART OF BOARD 13 (MOTHER BOARD)
14a
16a
10b
12b
CLOCK TO CONTROL LOGIC (SEE DRG.14)
CLOCK TO CONTROL LOGIC (SEE DRG.14)
RAMP UP FROM CONTROL LOGIC (SEE DRG.14)
DELAY STEERING FROM CONTROL LOGIC (SEE DRG.14)
ERROR STORE
2/5 of a 'mains' period after the start of ramp-up the input from Divide by 5 goes high clocking IC14b. The level on RAMP UP (high for slow clock) is then transferred to the Q output. IC10c and IC11a are enabled at the end of ramp down.
INCREASE CLOCK FREQUENCY
DECREASE CLOCK FREQUENCY
PART OF BOARD 13 (MOTHER BOARD)
9b
15b
13a
19a
24b
18
20b
20a
23b
+12 V
R35 100
+9 V
D23 9·1V
C13 22
C15 0·01
+5V TO ALL IC's PIN 14
C14 22
0V (B) TO IC1 PIN 7
0V (A) TO IC2 PIN 7
C17 22
R31 1k
R31 NOT FITTED ON A200/203
−12V
NOTES
BOARD 8 IC's
IC TYPE
1 836
2 862

DIVIDE BY 5 AND CLOCK DESCRIPTION 15

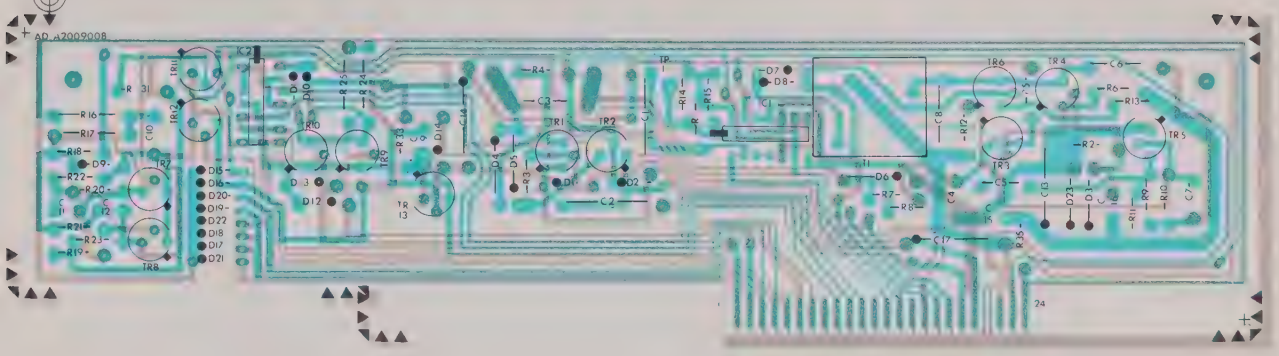


Fig.7.86 Pcb 8 A200, A203

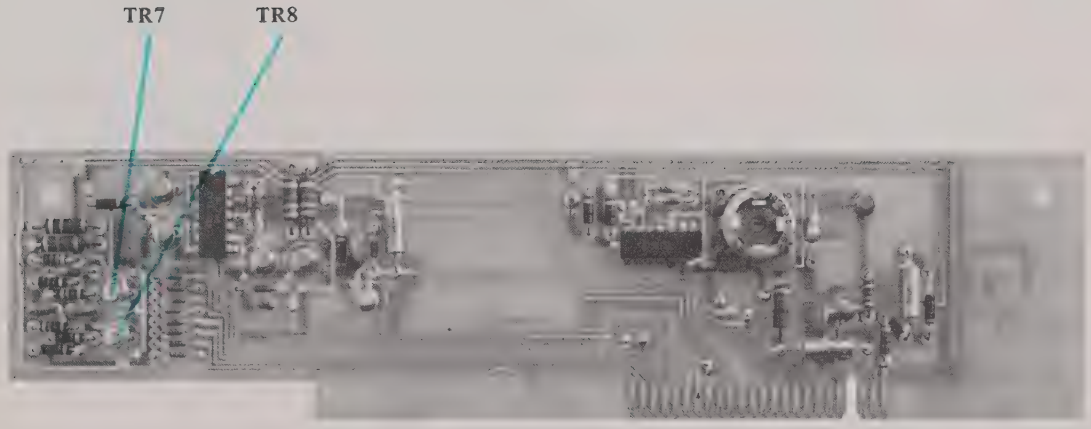


Fig.7.88 Pcb 8, A220, and A223

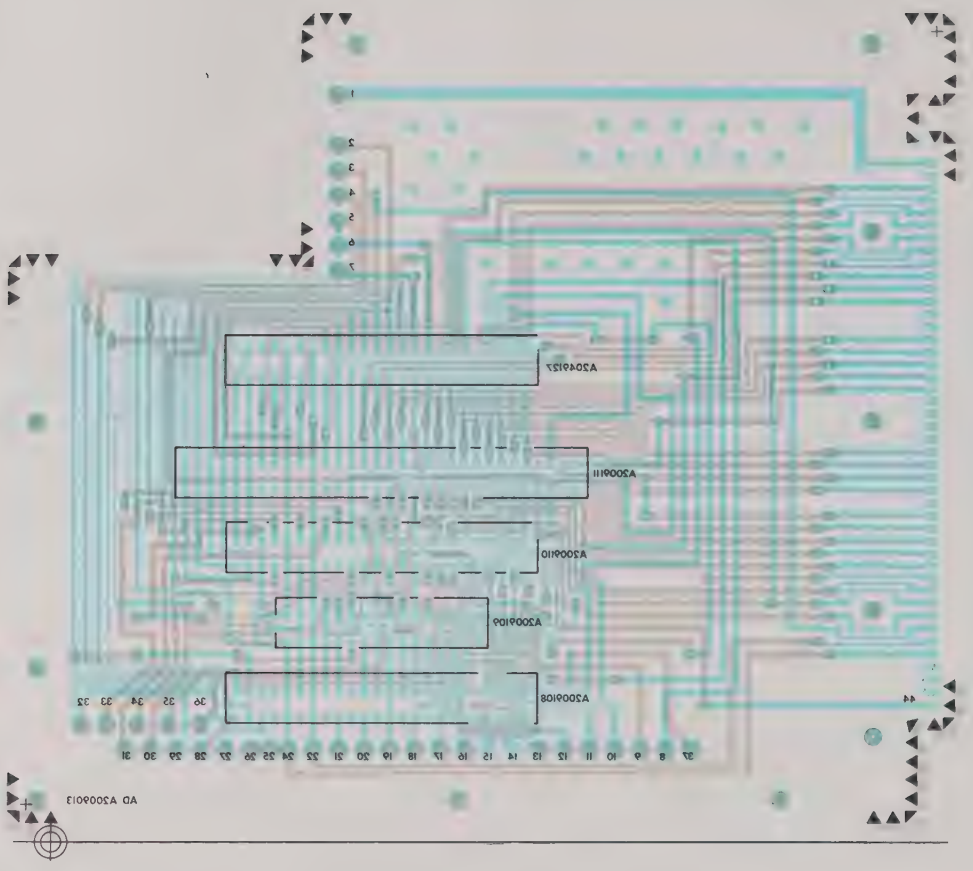


Fig.7.89 Pcb 13 Earthy Mother Board

Fig.7.91 Pcb 9 Divide by 5 and Error Store IC's.

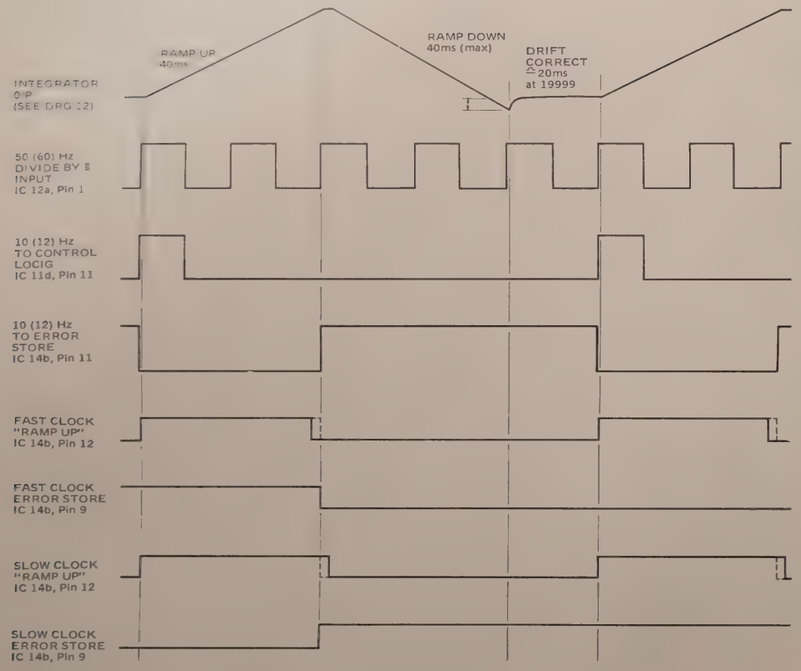
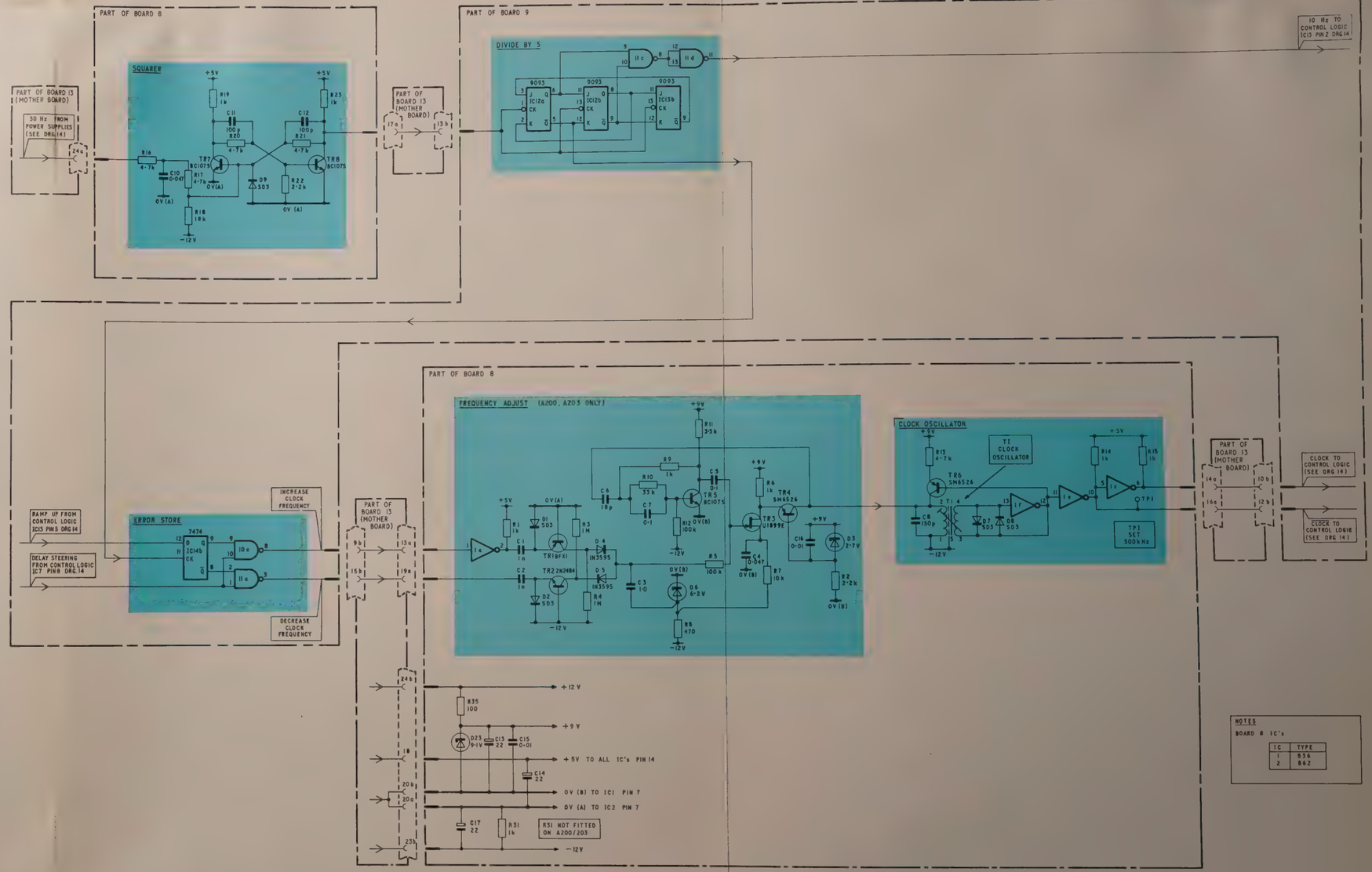
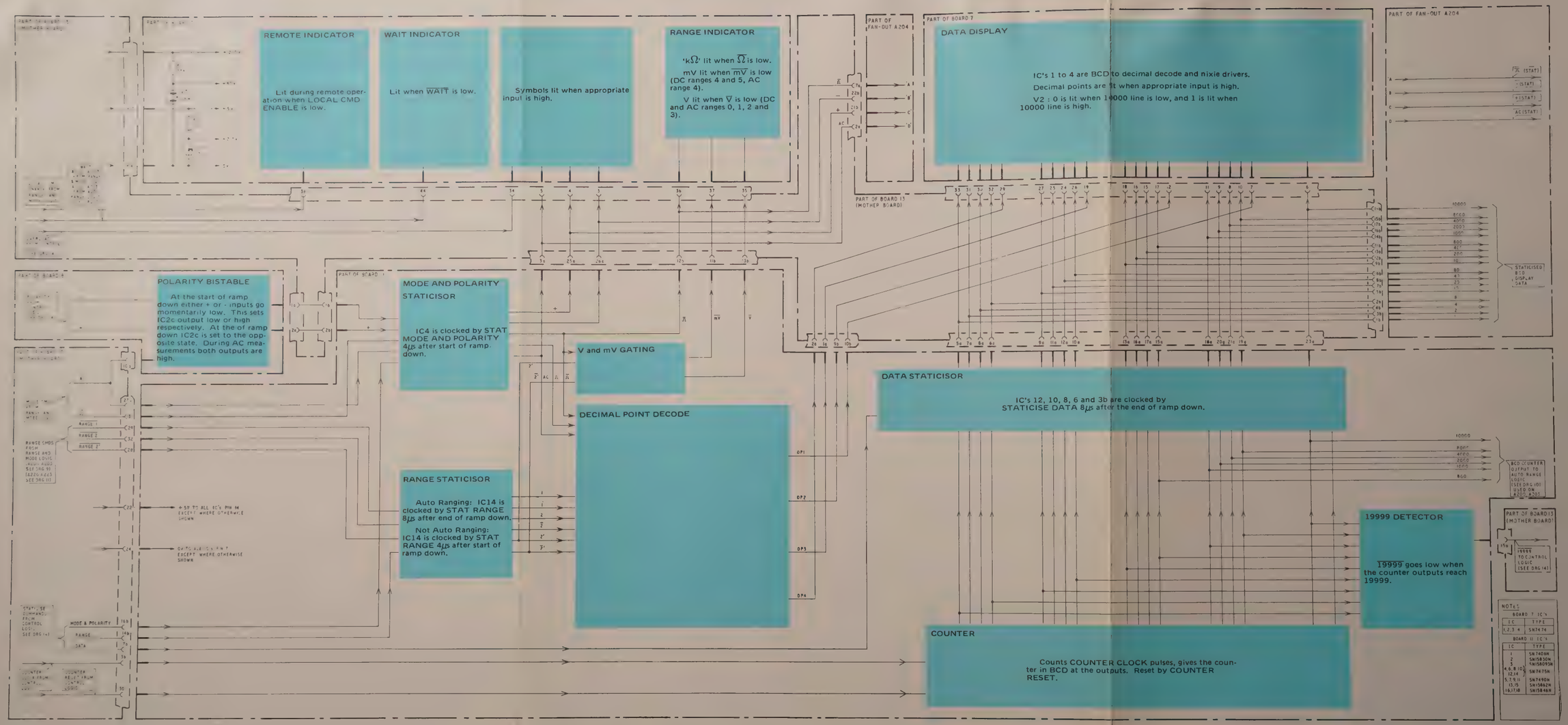

RAMP UP
40ms
RAMP DOWN
40ms (max)
DRIFT
CORRECT
≙20ms
at 19999
INTEGRATOR O/P (SEE DRG 12)
50 (60) Hz DIVIDE BY 8 INPUT IC 12a, Pin 1
10 (12) Hz TO CONTROL LOCIG IC 11d, Pin 11
10 (12) Hz TO ERROR STORE IC 14b, Pin 11
FAST CLOCK "RAMP UP" IC 14b, Pin 12
FAST CLOCK ERROR STORE IC 14b, Pin 9
SLOW CLOCK "RAMP UP" IC 14b, Pin 12
SLOW CLOCK ERROR STORE IC 14b, Pin 9

Fig.7.92 DIVIDE BY 5 AND CLOCK WAVEFORMS


PART OF BOARD 8
SQUARER
PART OF BOARD 13 (MOTHER BOARD)
50 Hz FROM POWER SUPPLIES (SEE DRG 14)
PART OF BOARD 9
DIVIDE BY 5
10 Hz TO CONTROL LOGIC IC13 PIN 2 DRG 14
RAMP UP FROM CONTROL LOGIC IC15 PIN 5 DRG 14
DELAY STEERING FROM CONTROL LOGIC IC7 PIN 8 DRG 14
ERROR STORE
INCREASE CLOCK FREQUENCY
DECREASE CLOCK FREQUENCY
FREQUENCY ADJUST (A200, A203 ONLY)
CLOCK OSCILLATOR
T1 CLOCK OSCILLATOR
TP1 SET 500kHz
CLOCK TO CONTROL LOGIC (SEE DRG 14)
+12V
+9V
+5V TO ALL IC's PIN 14
0V (B) TO IC1 PIN 7
0V (A) TO IC2 PIN 7
R31 NOT FITTED ON A200/203
−12V
NOTES
BOARD 8 IC's
IC TYPE
1 936
2 862

DIVIDE BY 5 AND CLOCK CIRCUIT 15


REMOTE INDICATOR
Lit during remote operation when LOCAL CMD ENABLE is low.
WAIT INDICATOR
Lit when WAIT is low.
Symbols lit when appropriate input is high.
RANGE INDICATOR
'kΩ' lit when Ω is low.
mV lit when mV is low (DC ranges 4 and 5, AC range 4).
V lit when V is low (DC and AC ranges 0, 1, 2 and 3).
PART OF FAN-OUT A204
PART OF BOARD 7
DATA DISPLAY
IC's 1 to 4 are BCD to decimal decode and nixie drivers.
Decimal points are lit when appropriate input is high.
V2 : 0 is lit when 10000 line is low, and 1 is lit when 10000 line is high.
PART OF FAN-OUT A204
PART OF BOARD 13 (MOTHER BOARD)
STATICISED BCD DISPLAY DATA
POLARITY BISTABLE
At the start of ramp down either + or - inputs go momentarily low. This sets IC2c output low or high respectively. At the of ramp down IC2c is set to the opposite state. During AC measurements both outputs are high.
MODE AND POLARITY STATICISOR
IC4 is clocked by STAT MODE AND POLARITY 4μs after start of ramp down.
V and mV GATING
DECIMAL POINT DECODE
DATA STATICISOR
IC's 12, 10, 8, 6 and 3b are clocked by STATICISE DATA 8μs after the end of ramp down.
RANGE STATICISOR
Auto Ranging: IC14 is clocked by STAT RANGE 8μs after end of ramp down.
Not Auto Ranging: IC14 is clocked by STAT RANGE 4μs after start of ramp down.
19999 DETECTOR
19999 goes low when the counter outputs reach 19999.
BCD COUNTER OUTPUT TO AUTO RANGE LOGIC (SEE DRG 101) USED ON A200, A201
PART OF BOARD 13 (MOTHER BOARD)
19999 TO CONTROL LOGIC (SEE DRG 141)
COUNTER
Counts COUNTER CLOCK pulses, gives the counter in BCD at the outputs. Reset by COUNTER RESET.
NOTES
BOARD 7 IC's
IC | TYPE
1,2,3 4 | SN7474
BOARD 12 IC's
IC | TYPE
1 | SN7406N
2 | SN1580N SN1580953N
5 | SN7475N
4,6,8 (10), 12,14 | SN7490N SN1582N SN1584N
5,7,9,11 13,15 16,17,18

COUNTER AND DISPLAY DESCRIPTION 16

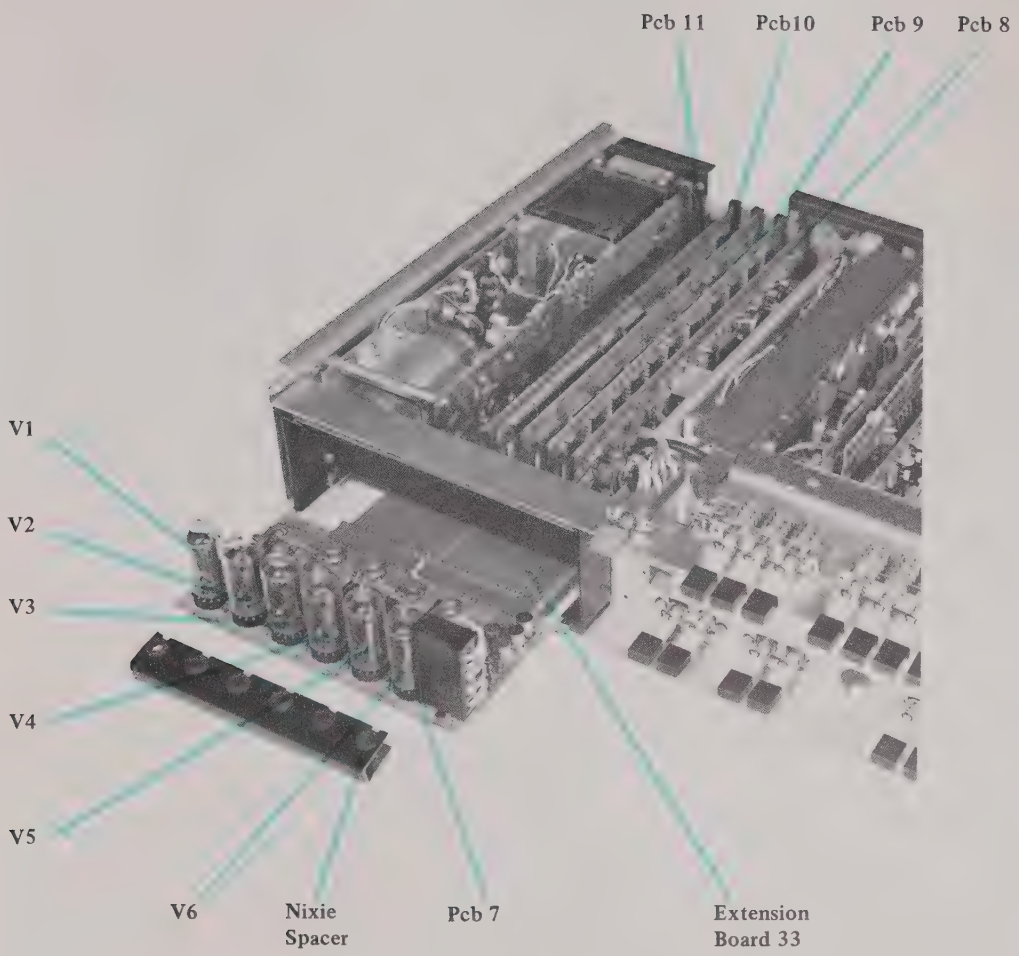


Fig.7.93 Pcb 7 on Extension Board 33

V1 to V6 Access

1) Remove the Top Cover.
2) Remove the two side handles.
3) Remove the Top Front Bar (A2000101).
4) Remove the Display Cover.

Ensuring the dvm is OFF, pcb 7 may now be eased from its socket using flat nosed pliers. If a Nixie Spacer is supplied, the tubes may be unplugged. If not, they can be readily unsoldered from the base and then removed.

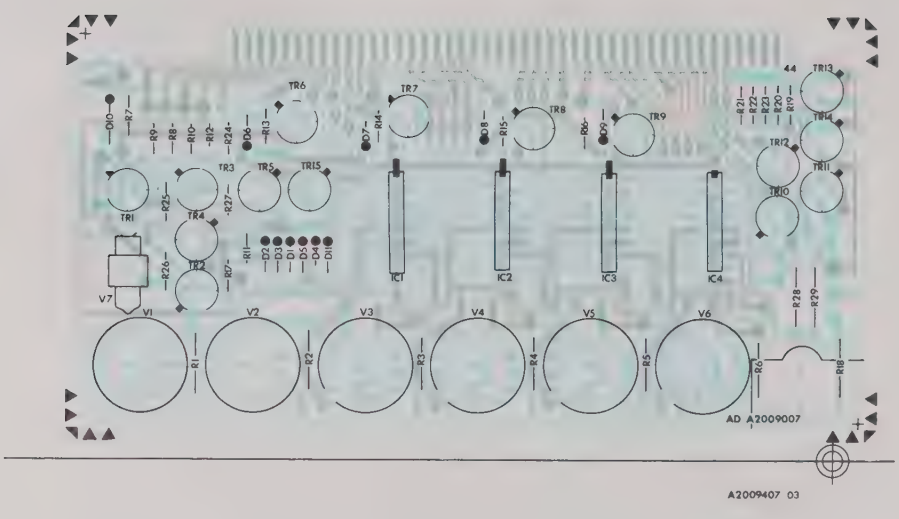
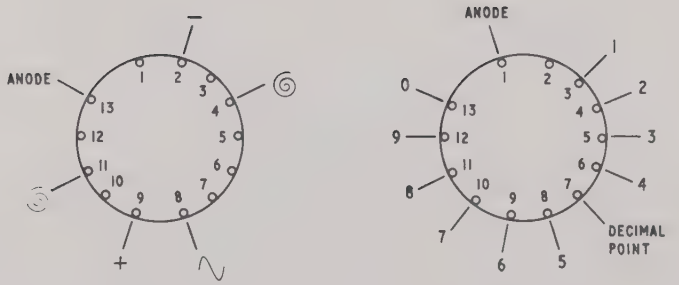


Fig.7.94 Pcb 7



ZM 1263/C ZM 175/C

Fig.7.96 Display Tube Bases

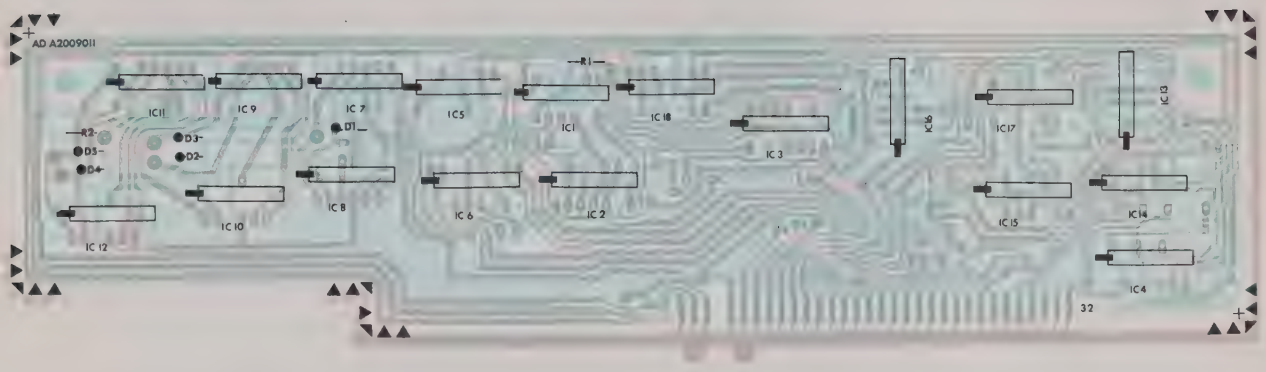


Fig. 7. 97 Pcb 11

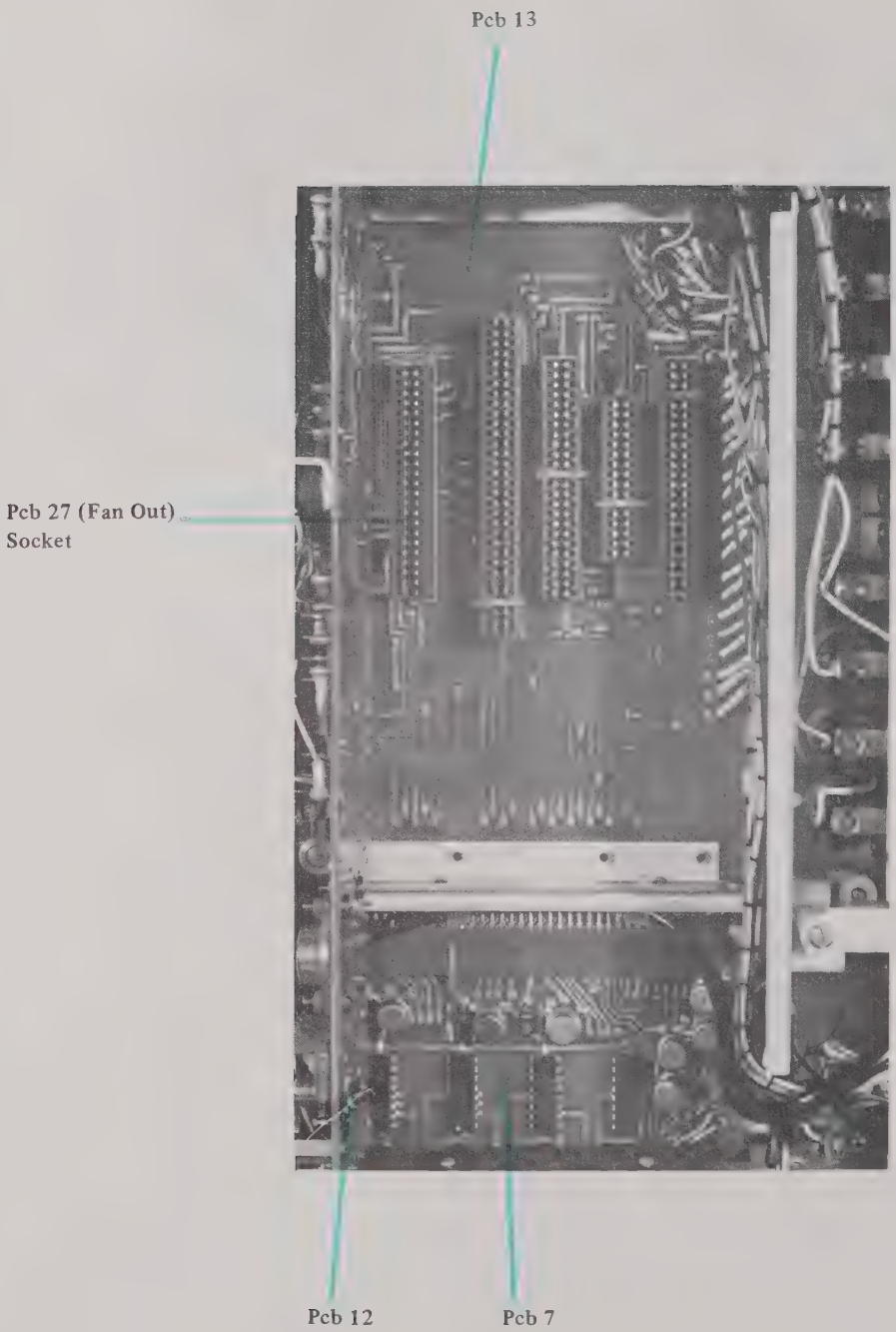
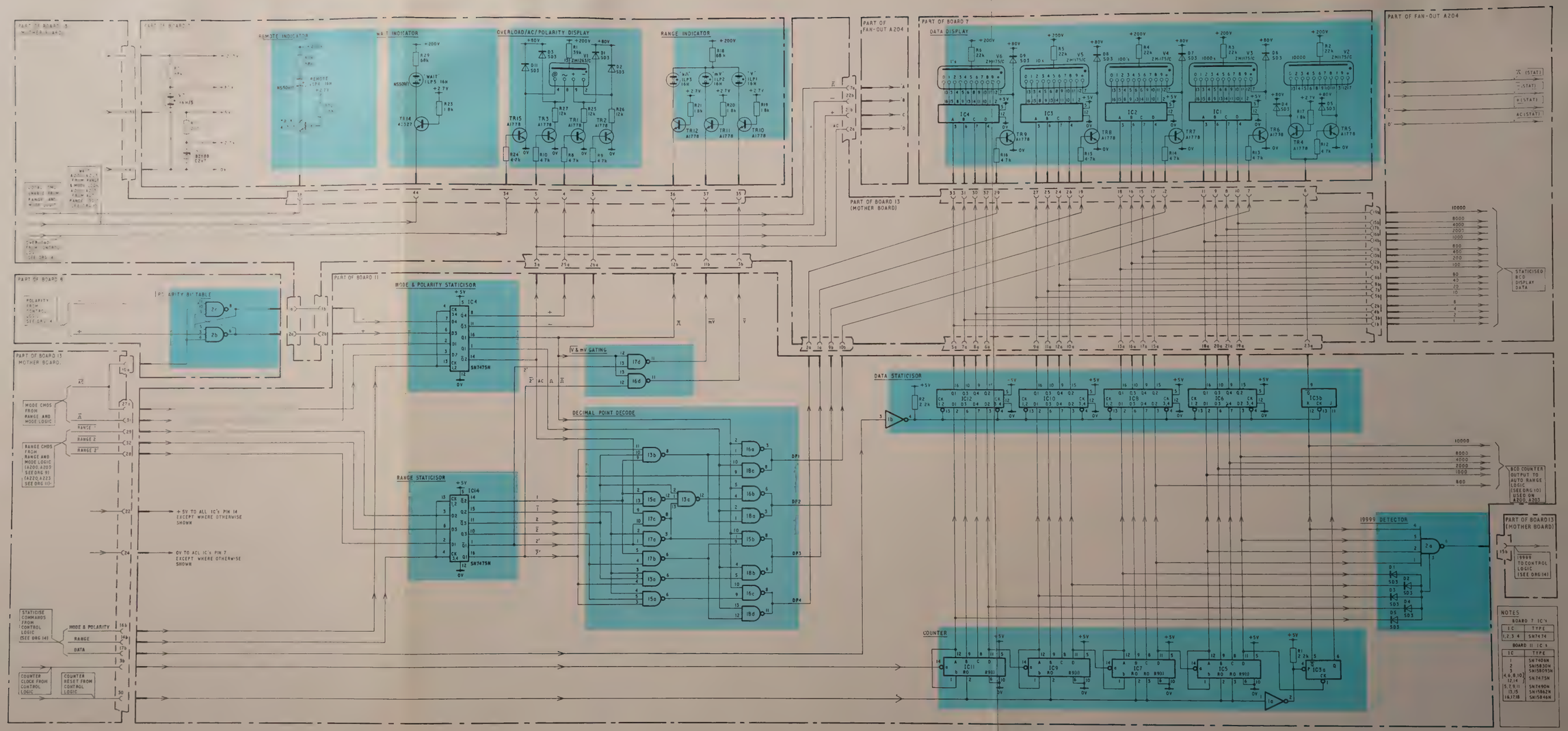
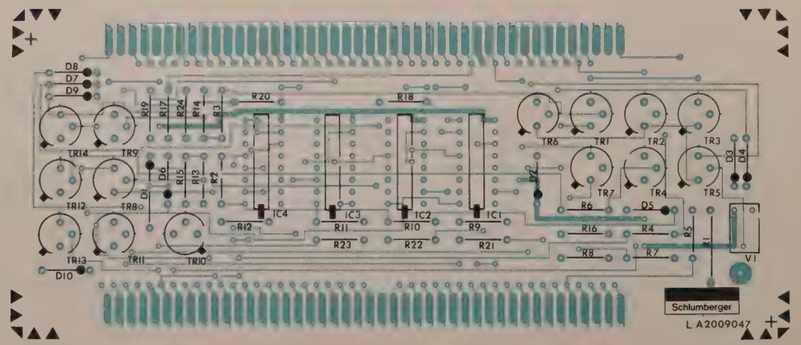


Fig.7.99 Pcb's 7, 12 and 13


REMOTE INDICATOR
WAIT INDICATOR
OVERLOAD/AC/POLARITY DISPLAY
RANGE INDICATOR
PART OF FAN-OUT A204
PART OF BOARD 7
DATA DISPLAY
PART OF BOARD 13 (MOTHER BOARD)
PART OF BOARD 11
MODE & POLARITY STATICISOR
V & mV GATING
DECIMAL POINT DECODE
RANGE STATICISOR
DATA STATICISOR
COUNTER
19999 DETECTOR
STATICISED BCD DISPLAY DATA
BCD COUNTER OUTPUT TO AUTO RANGE LOGIC (SEE DRG 10) USED ON A202, A203
19999 TO CONTROL LOGIC (SEE DRG 14)
MODE CMOS FROM RANGE AND MODE LOGIC
RANGE CMOS FROM RANGE AND MODE LOGIC (A200, A203 SEE DRG 9) (A220, A223 SEE DRG 11)
+5V TO ALL IC's PIN 14 EXCEPT WHERE OTHERWISE SHOWN
0V TO ALL IC's PIN 7 EXCEPT WHERE OTHERWISE SHOWN
STATICISE COMMANDS FROM CONTROL LOGIC (SEE DRG 14)
COUNTER CLOCK FROM CONTROL LOGIC
COUNTER RESET FROM CONTROL LOGIC
NOTES
BOARD 7 IC's
BOARD 11 IC's

COUNTER & DISPLAY (NIXIE) CIRCUIT 16a



Component layout pcb No. 47

16b READOUT DISPLAY (7 SEGMENT)

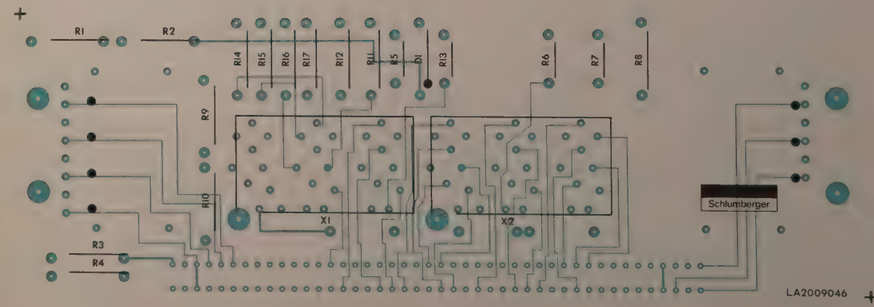
The output of the counter via the data staticiser, is converted to the 7 segment code necessary for display on indicators X1 and X2 by the decoder/drivers, IC's 1 to 4.

Each decoder/driver accepts the BCD information from the data staticiser (Board 11) and decodes it. The data are then used to drive the seven segments of the appropriate display without the need for other circuit elements.

The brightness level of the display is determined by resistors R9 to R12, (Board 47) which control the programmed current level to the segments. To ensure even brightness of all segments, the output segment current of the decoder/driver is ratioed to the output of segment b. (with segment b = 1.00 then segments a, f and g = 0.93, c = 1.25, d = 1.00 and e = 1.10).

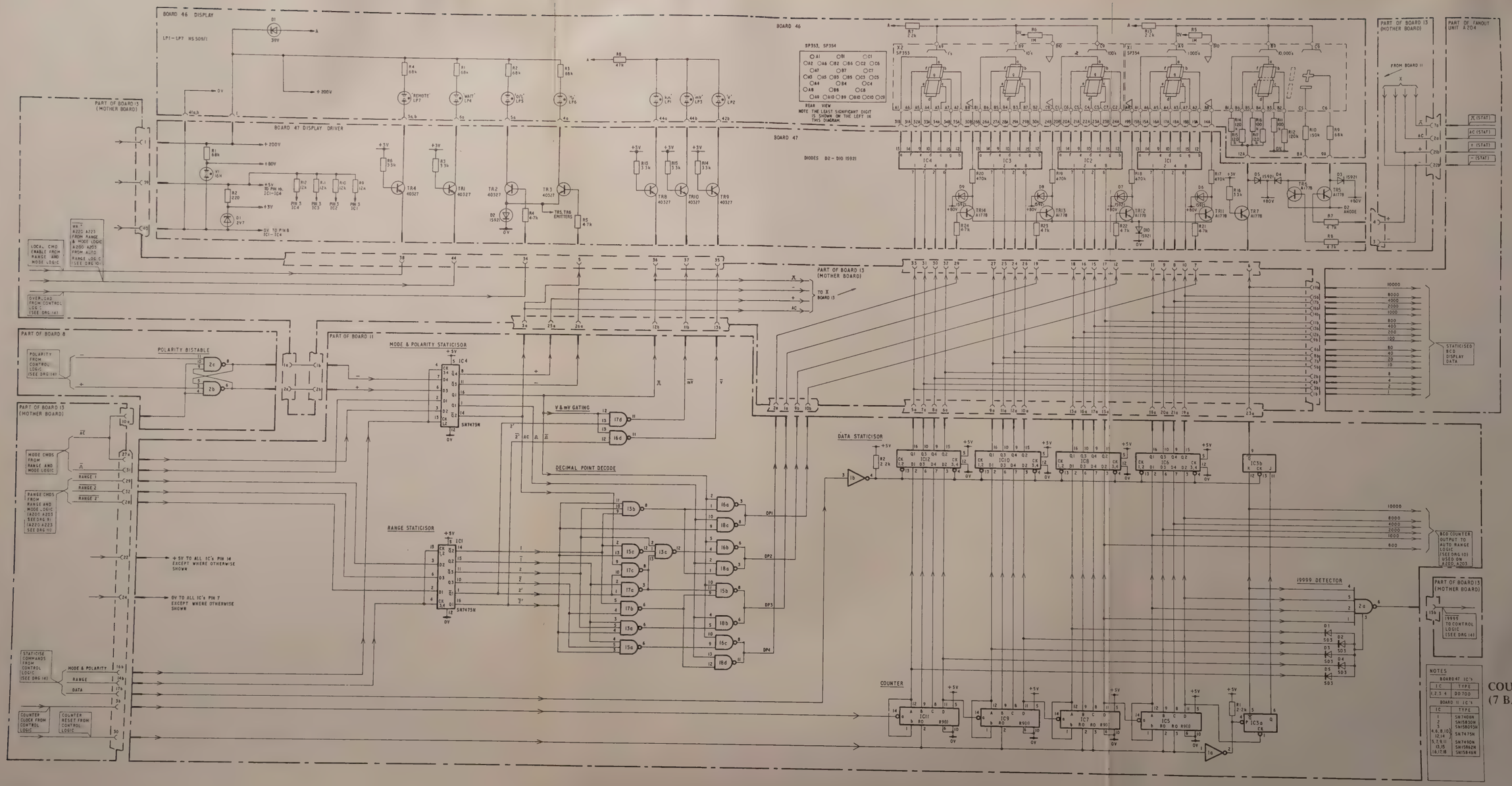
The decimal points of indicators X1 and X2 (the lower triangles) are driven from the decimal point decode circuit (Board 11). The upper triangles are "keep alive" cathodes which are used to ensure continuous ionisation of the indicators.

Diodes D3 to D5 protect transistors TR5 to TR7 by preventing the collector voltages from exceeding +88V.



Component layout pcb No. 46

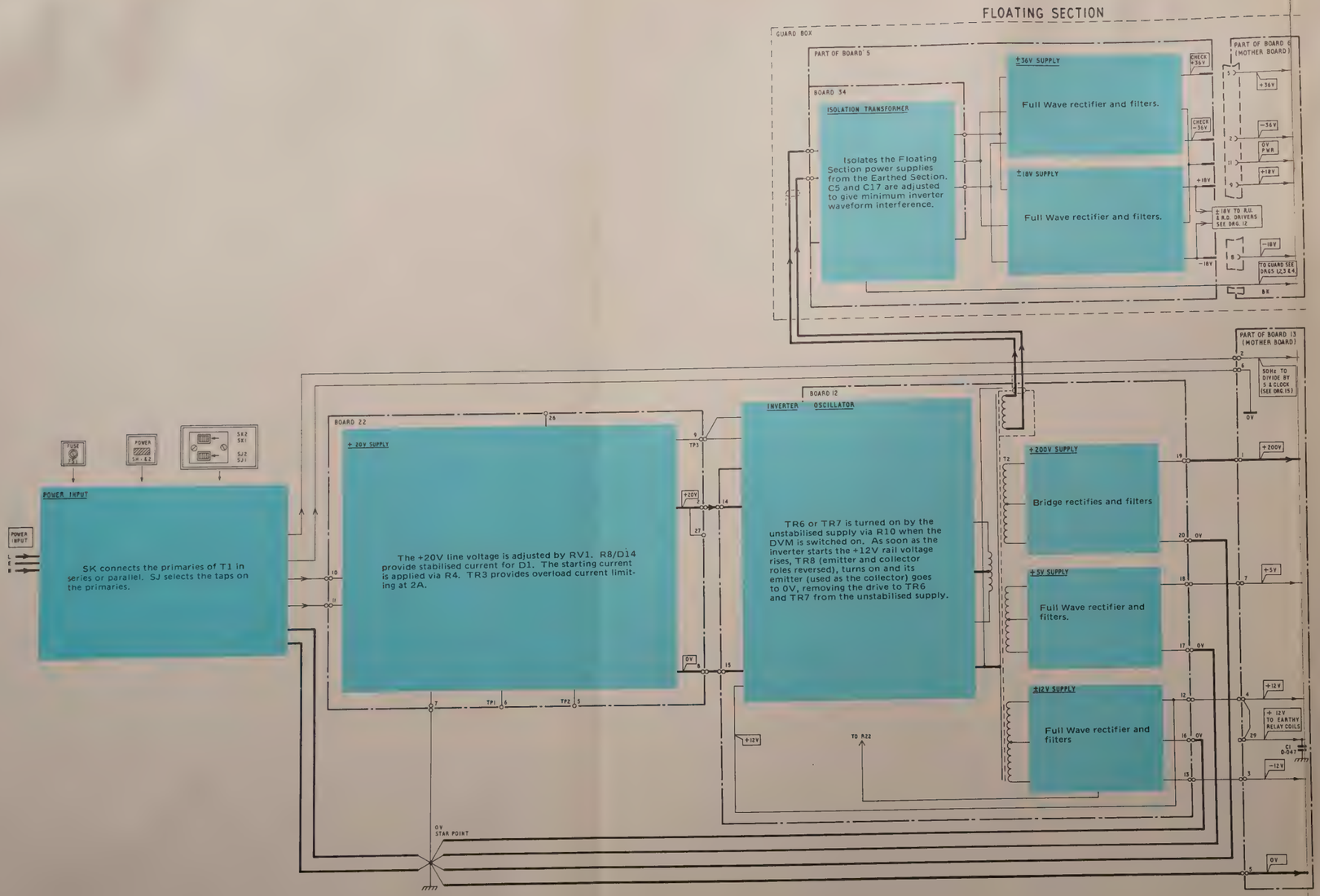
◀ Component layout pcb No. 47



COUNTER & DISPLAY (7 BAR) CIRCUIT 16

JR/A200/2

7.16.8


FLOATING SECTION
GUARD BOX
PART OF BOARD 5
BOARD 34
ISOLATION TRANSFORMER
Isolates the Floating Section power supplies from the Earthed Section. C5 and C17 are adjusted to give minimum inverter waveform interference.
±36V SUPPLY
Full Wave rectifier and filters.
±18V SUPPLY
Full Wave rectifier and filters.
CHECK +36V
CHECK -36V
+18V
-18V
±18V TO R.O. & R.O. DRIVERS SEE ORG. 12
TO GUARD SEE ORGS 1,2,3 & 4
PART OF BOARD 6 (MOTHER BOARD)
+36V
-36V
0V PWR
+18V
-18V
0V
BK
PART OF BOARD 13 (MOTHER BOARD)
50Hz TO DIVIDE BY 5 & CLOCK (SEE ORG 15)
0V
+200V
+5V
+12V
+12V TO EARTHY RELAY COILS
C1 0·047
-12V
0V
BOARD 12
INVERTER OSCILLATOR
TR6 or TR7 is turned on by the unstabilised supply via R10 when the DVM is switched on. As soon as the inverter starts the +12V rail voltage rises, TR8 (emitter and collector roles reversed), turns on and its emitter (used as the collector) goes to 0V, removing the drive to TR6 and TR7 from the unstabilised supply.
+200V SUPPLY
Bridge rectifies and filters
+5V SUPPLY
Full Wave rectifier and filters.
±12V SUPPLY
Full Wave rectifier and filters
T2
BOARD 22
+20V SUPPLY
The +20V line voltage is adjusted by RV1. R8/D14 provide stabilised current for D1. The starting current is applied via R4. TR3 provides overload current limiting at 2A.
TP3
+20V
0V
TP1
TP2
+12V
TO A22
POWER INPUT
SK connects the primaries of T1 in series or parallel. SJ selects the taps on the primaries.
FUSE
POWER SW. &2
SK2 SK1
SJ2 SJ1
0V STAR POINT

POWER SUPPLIES
DESCRIPTION 17

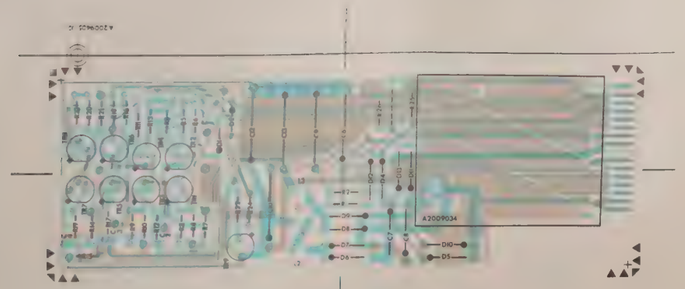


Fig.7.105 Pcb 5

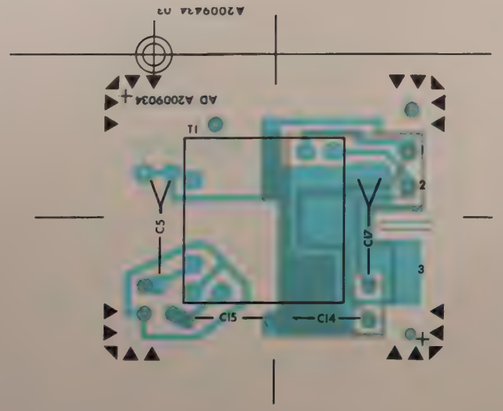
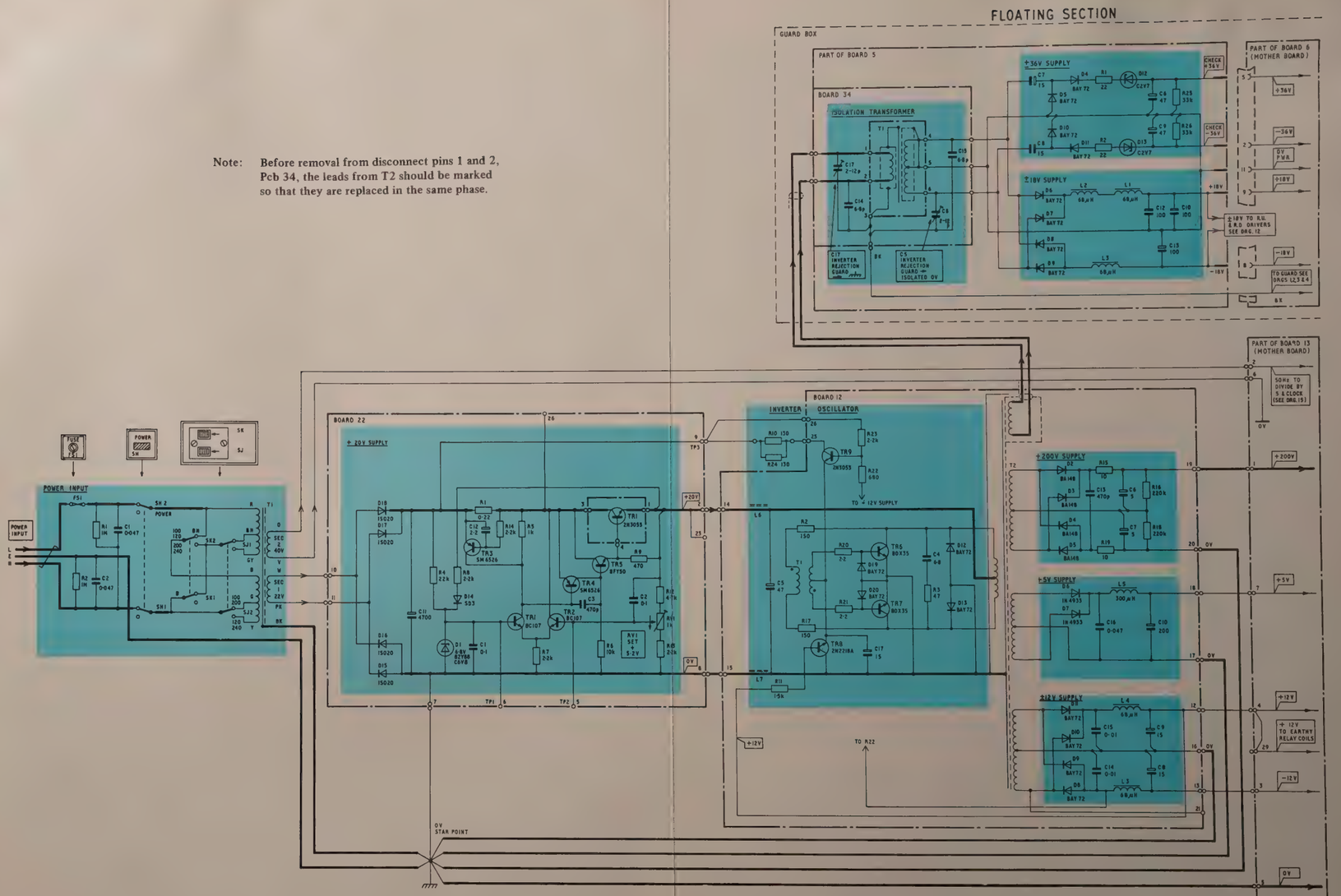
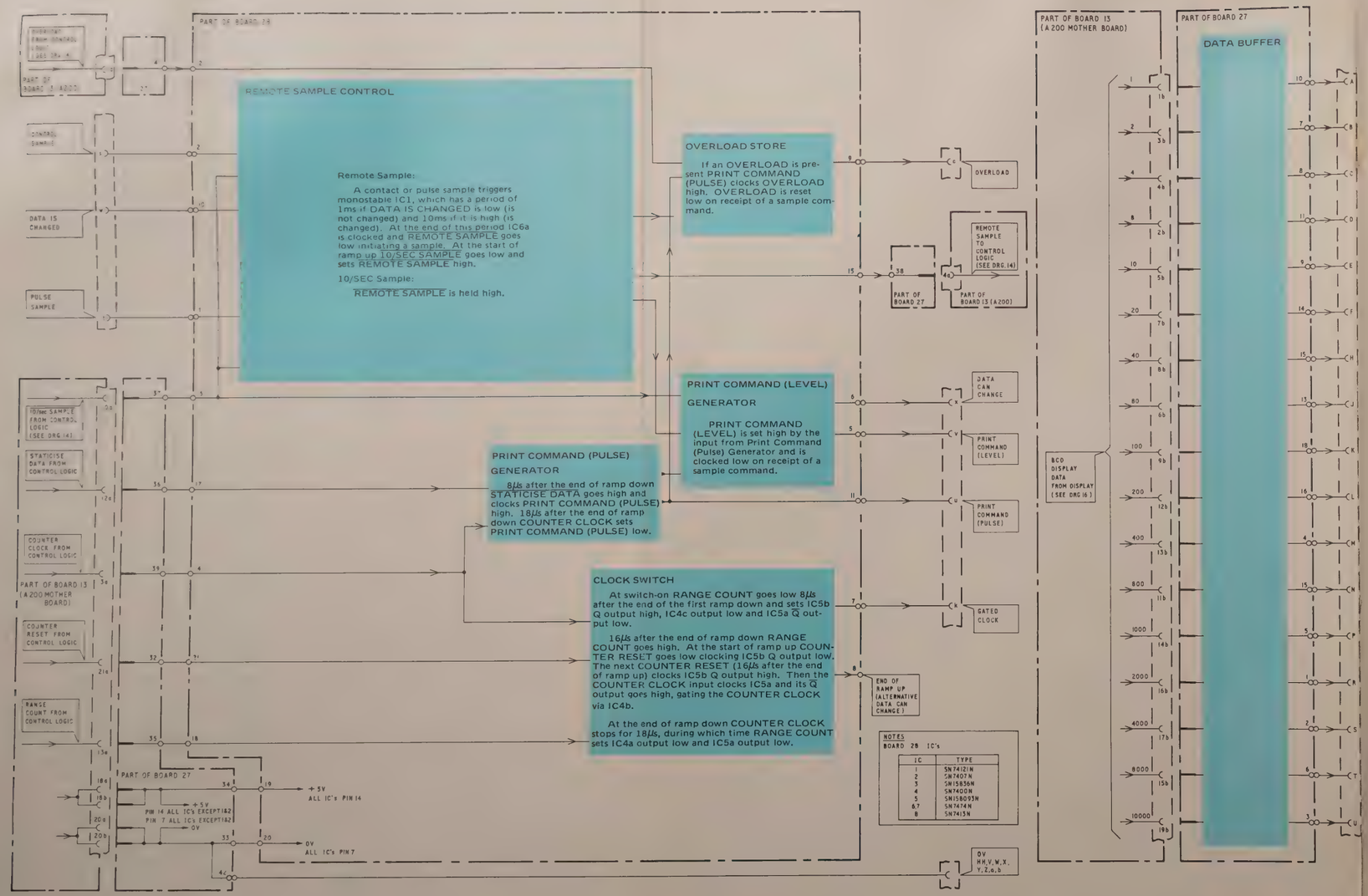
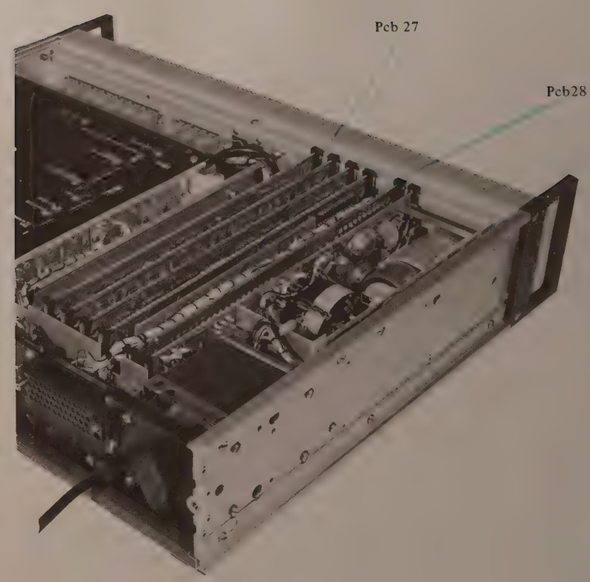


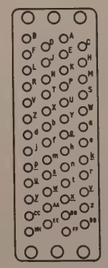
Fig.7.107 Pcb 34

Note: Before removal from disconnect pins 1 and 2, Pcb 34, the leads from T2 should be marked so that they are replaced in the same phase.




PART OF BOARD 28
REMOTE SAMPLE CONTROL
Remote Sample:
A contact or pulse sample triggers monostable IC1, which has a period of 1ms if DATA IS CHANGED is low (is not changed) and 10ms if it is high (is changed). At the end of this period IC6a is clocked and REMOTE SAMPLE goes low initiating a sample. At the start of ramp up 10/SEC SAMPLE goes low and sets REMOTE SAMPLE high.
10/SEC Sample:
REMOTE SAMPLE is held high.
OVERLOAD STORE
If an OVERLOAD is present PRINT COMMAND (PULSE) clocks OVERLOAD high. OVERLOAD is reset low on receipt of a sample command.
PRINT COMMAND (LEVEL) GENERATOR
PRINT COMMAND (LEVEL) is set high by the input from Print Command (Pulse) Generator and is clocked low on receipt of a sample command.
PRINT COMMAND (PULSE) GENERATOR
8μs after the end of ramp down STATICISE DATA goes high and clocks PRINT COMMAND (PULSE) high. 18μs after the end of ramp down COUNTER CLOCK sets PRINT COMMAND (PULSE) low.
CLOCK SWITCH
At switch-on RANGE COUNT goes low 8μs after the end of the first ramp down and sets IC5b Q output high, IC4c output low and IC5a Q output low.
16μs after the end of ramp down RANGE COUNT goes high. At the start of ramp up COUNTER RESET goes low clocking IC5b Q output low. The next COUNTER RESET (16μs after the end of ramp up) clocks IC5b Q output high. Then the COUNTER CLOCK input clocks IC5a and its Q̄ output goes high, gating the COUNTER CLOCK via IC4b.
At the end of ramp down COUNTER CLOCK stops for 18μs, during which time RANGE COUNT sets IC4a output low and IC5a output low.
PART OF BOARD 13 (A200 MOTHER BOARD)
PART OF BOARD 27
DATA BUFFER
BCD DISPLAY DATA FROM DISPLAY (SEE DRG 16)
OVERLOAD
REMOTE SAMPLE TO CONTROL LOGIC (SEE DRG 14)
DATA CAN CHANGE
PRINT COMMAND (LEVEL)
PRINT COMMAND (PULSE)
GATED CLOCK
END OF RAMP UP (ALTERNATIVE DATA CAN CHANGE)
0V M,H,V,W,X, Y,Z,a,b
+5V ALL IC's PIN 14
0V ALL IC's PIN 7
NOTES BOARD 28 IC's
IC TYPE
1 SN7421N
2 SN7407N
3 SN15836N
4 SN7400N
5 SN15809JN
6,7 SN7474N
8 SN7415N



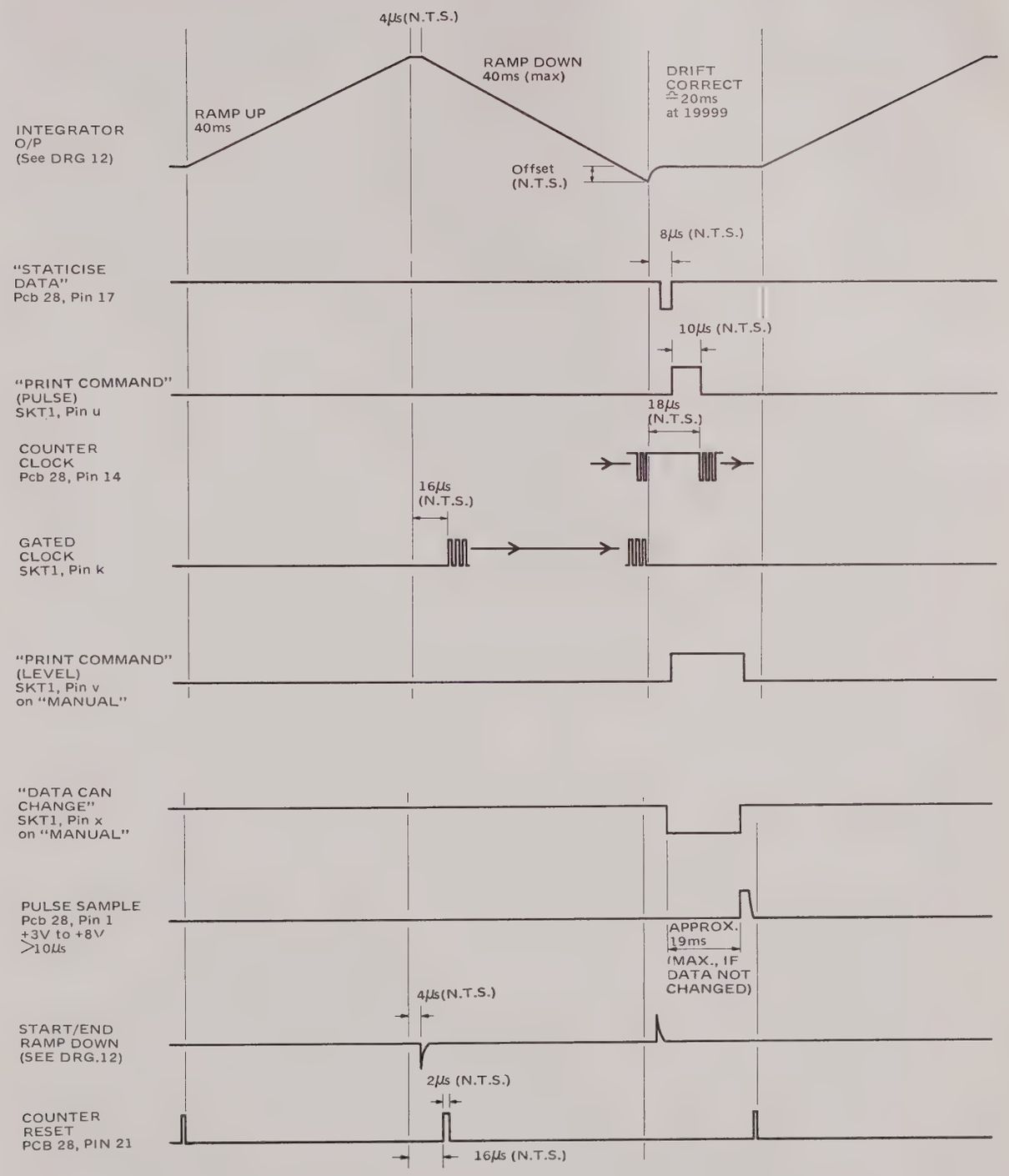


A204 Socket (SKT1) Notation

Fig.7.109 A204 Fan out Installation and Socket Notation

Pcb 27 fits the vacant Pcb 13 Socket, A2049127, see Fig.7.99. The 50-WAY Fan Out Socket (SKT1) fits in place of the rear panel Blanking Plate.

A204 FAN OUT
SHEET 1
DESCRIPTION



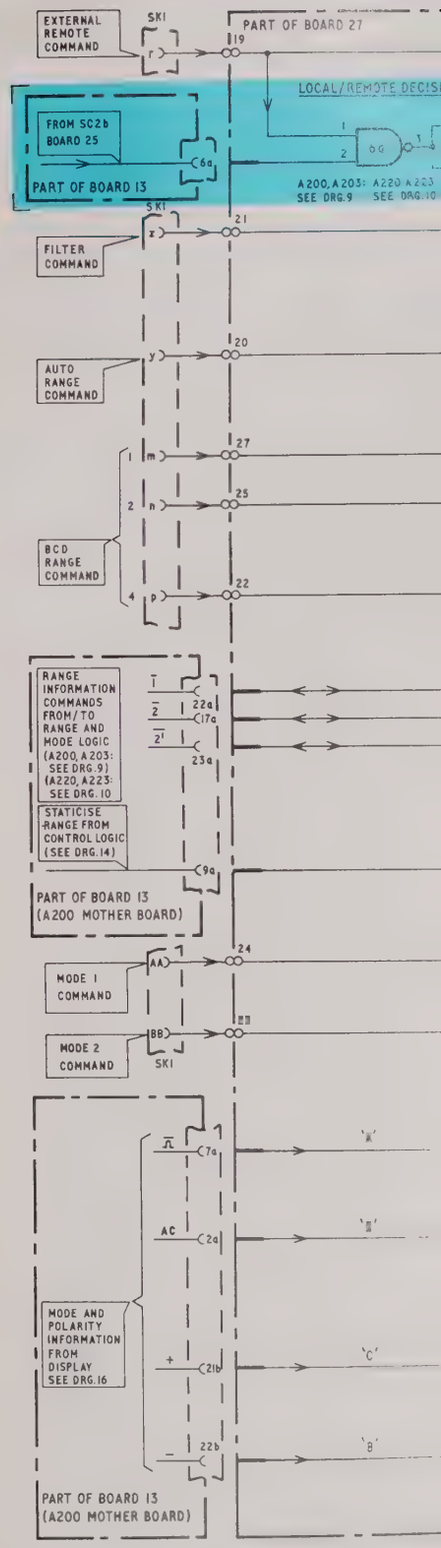
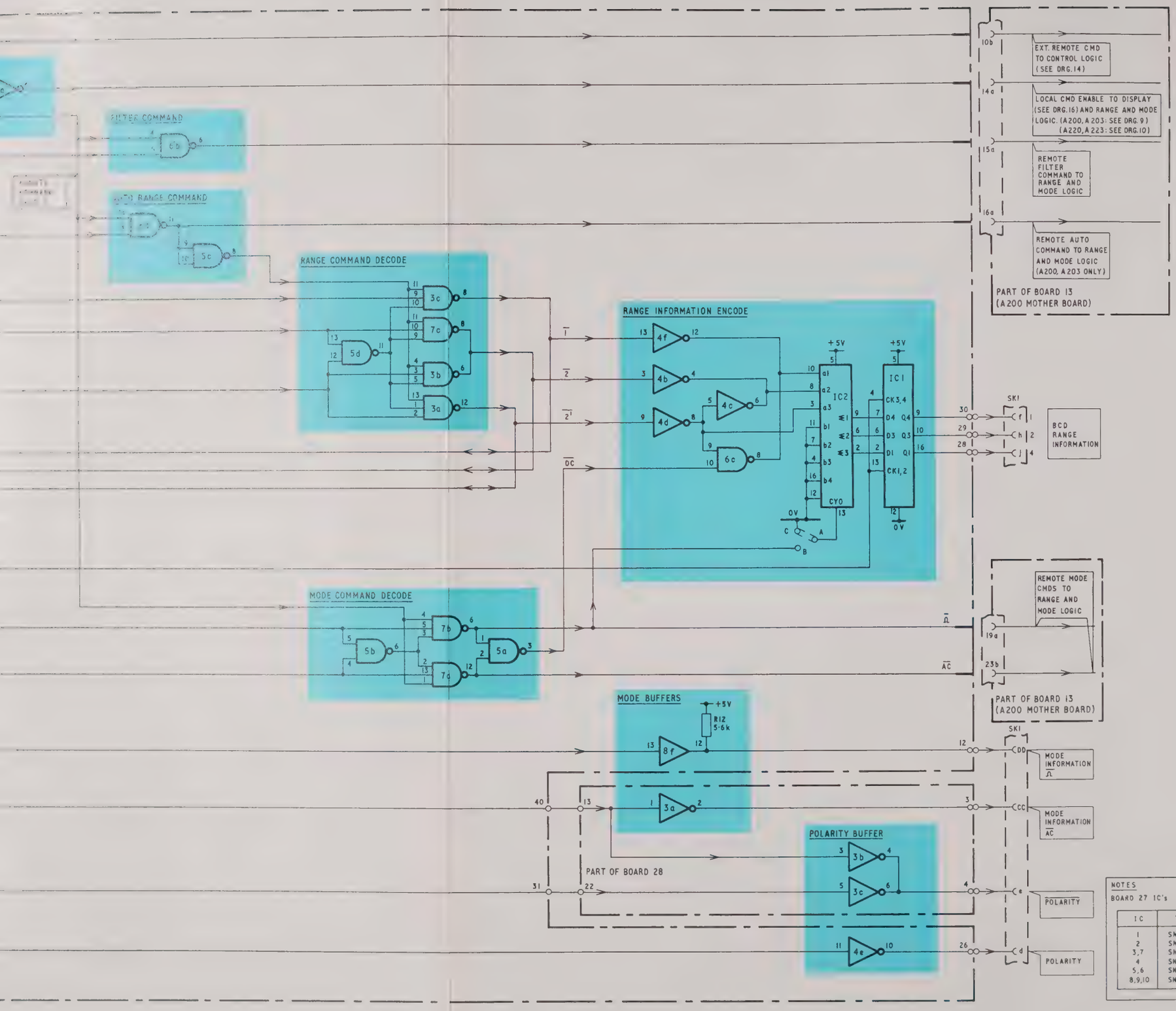


Fig.7.113 A204 FAN OUT WAVEFORMS



A204 FAN OUT
SHEET 2
CIRCUIT

SECTION 8 Test Specification

CONTENTS

		Page
A	Initial Calibration	8.2
B	DC Final Calibration	8.13
C	AC and Ω Final Calibration (A203 and A223 only)	8.15
D	Testing The A204 Fan Out Unit	8.18
E	Appendix, Test Equipment	8.24
F	AC Calibration (A205/A225)	8.28

Multimeter, 2% Grade, 20 000Ω/volt, e.g. AVO Model 8.

Frequency Counter, to 1MHz and 10ppm accuracy.

Oscilloscope, dc to 30MHz, e.g. Solartron A100.

Thermocouple Thermometer, 2% Grade, e.g. Comark 1621.

D.C. Calibrator, ± 0.003% accuracy, e.g. COHU 351

A.C. Calibrator, from ± 0.02% accuracy, e.g. Hewlett Packard 745A with Hewlett Packard 746A

Pulse Generator, up to 200kHz, 20ns rise time, e.g. Solartron 1101.2

EX 3193 Connector, 3 way Input Lead (Solartron).

Kelvin Varley Divider, 10kΩ, 5ppm grade, e.g. ESI Dekavider RV622A.

Decade Resistance Standard, 0.005% grade, e.g. ESI RS624.

Standard Resistors,

9 x 2MΩ,	0.1%*	
1.8MΩ,	0.01%*	* Known uncertainty.
180kΩ, 18kΩ, 1.8kΩ,	0.003%*	

Precautions

Short circuits either across power rails or from power rails to ground (0V) will blow the fuse. If the Inverter Oscillator stops switch OFF and then ON.

Check for short circuits on the rails.

Check the connections from inverter board (pcb 12) to the earthy mother board (pcb 13) of the rails. (See Drg. 17).

Remove pcb 2 from the floating section.

For the purpose of test and calibration Model A227 is identical to the A220.

For Models A205 and A225 see section F on page 8.28.

A. INITIAL CALIBRATION

1. POWER SUPPLIES

1.1 Switch OFF.
Set mains voltage selector to 220 - 255V rms.
Check that a 250mA (300mA)* fuse is fitted.
Connect the DVM to the mains via a variac.
Set the variac to 230V rms and switch ON.

1.2 Measure the voltage on pin 18 of pcb 12 with respect to 0V.
Adjust RV1 on pcb 22 to obtain a reading of +5.2V ± 0.1V.

1.3 Increase the variac output to 250V and check that the +5V rail voltage remains constant.

1.4 Switch OFF.
Set the mains voltage selector to 195 - 230V rms.
Reduce the variac output to 200V rms.
Switch ON.
Check the 5V rail voltage is +5.2V ± 0.1V

1.5 Repeat 1.4 with the mains voltage selector set to 98-115V and the variac output set to about 100V rms and a 500mA (750mA)* fuse fitted.

1.6 Repeat 1.5 with the mains voltage selector set to 100-128V and the variac output set to about 115V rms.

1.7 Switch OFF.
Reset the mains voltage selector to 220-255V and the variac to 230V rms and fit a 250mA (300mA)* fuse. Fit the 220-255V mains selector plate.

1.8 Switch ON.
Check the +36V and -36V rails in the floating section.

1.9 Switch OFF.
Fit pcb 2 and switch ON.

* As indicated on MAINS SELECTOR PLATE

2. CLOCK OSCILLATOR

NOTE	Pcb 8	50Hz	60Hz
	C8	150p	100p
*A200, A203 only	C6*	18p	10p

2.1 (A200, A203)
Short circuit C3 on pcb 8.
Switch ON.
Adjust T1 on pcb 8 to give a 500kHz (600kHz from 60Hz mains supply) square wave signal at the output of IC1e (TP1). (See Drg. 15).

3. BASIC OPERATION

3.1 Switch ON.
Switch to DC, 10/SEC. FAST.
Short circuit the High and Low input terminals.
Switch to each range in succession and check that the decimal points, V and mV signs are clear and correct.

3.2 Switch to AC. (A203, A223)
Repeat 3.1 (10mV range is the same as 100mV.)
Check that the AC sign appears clearly.

3.3 Switch to Ω . (A203, A223)
Check that the kΩ sign appears.
Switch to each range in succession and check that the decimal points appear correctly.
(10mV range is the same as 1kΩ).

3.4 A200/A203 only.
Switch to 1000V DC range.
Apply approximately +1mV to the input.
Switch to AUTO range.
Check that the reading is approximately correct.
Increase the input to obtain more than 19000 digits.
Check that the range changes to 100mV.
Decrease the input to less than 1800 digits.
Check that the range changes back to 10mV.

3.5 Switch to DC and the 10V range.
Apply approximately +1V to the inputs.
Check that the polarity sign is clear and correct.
Reverse the polarity of the input.
Check that the polarity sign is clear and correct.

3.6 Switch to MANUAL sample. Vary the applied input.
Check that the reading remains unchanged, (including polarity).
Operate MANUAL sample once.
Check that the new reading is now obtained. (Polarity signs, decimal points, V and mV all changed only after initiating the sample).
Apply 100mV input on the 10mV range.
Check that the overload sign appears without sampling.

3.7 A200/A203 only.
Switch to SLOW filter, 10V range, MANUAL.
Apply approximately +1V to the input.
Operate MANUAL sample once.
Check that the WAIT sign appears for about 1s before the new range is displayed.
Switch to AUTO range.
Operate MANUAL sample once.
Check that the WAIT sign appears (may be flashing) until the correct reading is staticised.

4. INPUT AMPLIFIER (pcb 2)

NOTE: A200/A203 TR1 and TR3 are selected for $< 0.3\ \mu V$ rms noise using TG 1030 (see APPENDIX).

4.1 A200/A203 only. (See Drg. 6)
Switch OFF.
Short circuit the High and Low input terminals.
Short circuit the junction of R1 and C1 to 0V.
Switch to DC.
Connect a source of 10mV between the junction of R1 and R11 and 0V.
Connect an oscilloscope set to 5mV/cm to T.P.I.
Switch ON.
Adjust RV2 to obtain a maximum amplitude square waveform.
Remove the input and the short circuit.

4.2 A200/A203 only.
Measure the voltage across C9.
If the voltage exceeds 1.8V, cut the link across R50.

4.3 Fit Amplifier Screen.

4.4 Switch to 10/SEC. DC, SLOW filter, 10mV range. (100mV range on A220/A223).
Connect 1MΩ in parallel with 1μF across the input terminals.
Adjust RV1 for minimum input current, (less then 20μV reading i.e. 2×10^{-11}A).

5. INTEGRATOR (pcb 3, see Drg. 12)

5.1 Insert a thermocouple probe into the holes provided in the oven heat sink.
Carefully adjust RV1 to obtain a temperature of 77 ± 1^{o}C, using the Thermocouple Thermometer; clockwise increases temperature. The adjustment is fairly critical; allow time for the reading to settle. *This is not done on later models where RV1 is ommitted.*

(Note: Remove pcb 2, or use Extension Board A2009033 for access to RV1)

5.2 Reference Adjustment.
Switch to 10V range, FAST filter, DC.
Connect input leads to a voltage source. (e.g. COHU 351 set to +10.0000V and RV622A).
Apply an input of 5.651V. (Set RV622A to 5,6,5,1,0,0).
Note the reading.
Using table 1, cut the appropriate links and also the link by the side joining pin 11 to TR3 (See Drg. 5).

Table 1

Reading Between	Cut Link Across				
	R46	R45	R44	R43	R42
19.2976------19.1556	*	*	*	*	*
19.2206------19.0854	*	*	*	*	-
19.1506------19.0213	*	*	*	-	*
19.0867------18.9626	*	*	*	-	-
19.0281------18.9087	*	*	-	*	*
18.9743------18.8590	*	*	-	*	-
18.9245------18.8130	*	*	-	-	*
18.8785------18.7703	*	*	-	-	-
18.8084------18.6699	*	-	*	*	-
18.7414------18.6086	*	-	*	-	*
18.6802------18.5525	*	-	*	-	-
18.6241------ 18.5009	*	-	-	*	*
18.5725------18.4533	*	-	-	*	-
18.5248------18.4092	*	-	-	-	*
18.4807------18.3683	*	-	-	-	-
18.4135------18.2722	-	*	*	*	-
18.3493------18.2135	-	*	*	-	*
18.2906------18.1597	-	*	*	-	-
18.2368------18.1102	-	*	-	*	*
18.1873------18.0646	-	*	-	*	-
18.1416------18.0224	-	*	-	-	*
18.0993------17.9832	-	*	-	-	-
18.0349------17.8911	-	-	*	*	-
17.9732------17.8348	-	-	*	-	*
17.9169------17.7832	-	-	*	-	-
17.8653------17.7357	-	-	-	*	*
17.8178------17.6920	-	-	-	*	-
17.7740------17.6515	-	-	-	-	*
17.7333------17.6139	-	-	-	-	-

* = Cut Link

5.3 Set the standard voltage source to +10.0005V.
Adjust RV5 **(Drg.5)** to obtain a flicker between +10.000 and +10.001.
Change the polarity of the input.
Adjust RV4 **(Drg. 12)** to obtain a flicker between -10.000 and -10.001.

5.4 Offsets.
Switch to DC.
Apply an input of +10.5mV from the voltage source.
Adjust RV2 to obtain a flicker between +10 and +11 digits.
Reverse the polarity of the input.
Adjust RV3 to obtain a flicker between -10 and -11.

5.5 Repeat 5.3 and 5.4 until no further adjustment of RV2 and RV3 is necessary.

5.6 Reduce input to zero.
Check that the reading is ± 00.000V, (polarity sign flickers).
Increase the input in - 0.1mV steps to - 0.3mV.
Check that the instrument displays - 00.000V.
(Note: R29 on pcb 3 is selected in test for correct zero reading, its value being 10kΩ, 12kΩ or 15kΩ).
Apply an input of +10.000V using a divider box. Reduce the divider box ratio in 1% steps and check that the reading is correct to within 1 digit.
Repeat for opposite polarity.
Also check that the numbers are clearly displayed in all the windows.

6. FLOATING SECTION

If boards have been disturbed reposition them carefully and fit the top cover.

6.1 Switch to DC.
Set the μV OFFSET to the centre of its swing.

6.2
a) Connect a 10kΩ resistor between Low and mains earth.
Short circuit High to Low.
Connect an oscilloscope probe to the Guard Box.
Adjust C17 on pcb 34 (See Drg. 17) to obtain minimum 25kHz spike waveform, (approximate amplitude 10mV).

b) Remove the oscilloscope probe from the Guard Box and connect to 0V Pwr (pin 30, pcb 6), connecting oscilloscope low to Guard Box.

Adjust C5 pcb 34 for minimum 25kHz spikes (approximately 10mV).

(Note: On the A203 and A223, C5 may be set for zero reading on the 1MΩ and 10MΩ Ranges, FAST filter.

c) Select 10mV range, FAST filter (100mV Range on the A220). Short the input leads together and connect them to the Pulse Generator via a 1MΩ resistor.

Set the Pulse Generator to square wave, 3.5Hz and 30V amplitude.

Adjust C6 pcb 26 (see Drg. 5) for optimum common mode rejection (minimum scatter on the dvm reading).

On the A220 and A223, set C6 half way if no scatter is observed.

Ensure that C6 lead (Black) to mains earth is dressed for shortest length inside the Guard Box.

6.3 Switch to 10mV range and SLOW filter. (100mV range on A220/A223).
Note the reading.
Switch to FAST filter.
Adjust RV2 on pcb 6 to obtain the same reading as above, making the appropriate link on the back of pcb 6 (See Drg. 5).
Repeat until they are the same, (with fast and slow filter).

6.4 Switch to SLOW filter.
Adjust the μV OFFSET pot. to obtain ± 00.000mV.
Check that the μV OFFSET pot. covers more than 10 digits on either side of zero. (5 digits on A220 and A223).
Reset zero.
Check that the instrument reads zero on all ranges with either filter.

7. RANGE CALIBRATION

Switch to DC.

Apply input voltages as shown below and adjust corresponding pots. to obtain the reading given. (If a source of more than 10V is not available, use 10.000V on 10V range).

Test	Range	Filter	Input	Adjust	pcb	Drawing	Reading	±
7.1	10V	FAST	+18.0005V	RV5	3	5	+18.000/1	
			- 18.0005V	RV4	3	12	- 18.000/1	
*7.2	10mV	SLOW	+18.000mV**	RV3	26	5	+18.000	3
			- 18.000mV**				- 18.000	3
	10mV	FAST	+18.000mV				+18.000	4
			- 18.000mV				- 18.000	4
7.3	100mV		+180.00mV	RV2	26	5	+180.00	2
			- 180.00mV				- 180.00	2
7.4	1V		+1.8000V	RV1	26	5	+1.8000	1
			- 1.8000V				- 1.8000	1
7.5	100V		+180.00V	RV1	6	1 & 2	+180.00	1
			- 180.00V				- 180.00	1
7.6	1000V		+1200.0V				+1200.0	1
			- 1200.0V				- 1200.0	1

* A200/A203 only

** Mean reading to be 18000

8. INPUT IMPEDANCE

8.1 Switch to 10V range, FAST filter and DC.

Apply an input signal directly to the input terminals to obtain a 10.000V reading.

Reapply the same input via 1MΩ in parallel with 1μF.

The change in reading should be less than 1 digit.

Repeat with the SLOW filter.

The change in reading should be less than 1 digit.

8.2 Repeat 8.1 on the 1V range with an input of 18000 digits.

The change in reading should be less than 2 digits.

8.3 Repeat 8.1 on the 100mV range with an input of 18000 digits.

The change in reading should be less than 12 digits.

Repeat on opposite polarity.

The change in reading should be less than 12 digits.

The average of the two readings should be less than 2 digits.

9. NOISE LEVEL (A200/A203 only)

9.1 Switch to 10mV range, FAST filter and DC.

Apply an input of approximatley 10μV.

The indicated reading should not jitter by more than 2μV, (i.e. 4 digits).

9.2 Switch to SLOW filter.

The indicated reading should not jitter by more than 1μV, (i.e. 3 digits).

With adjustment of the μV OFFSET pot. of ½ bit it should be possible to obtain a flicker of 2 digits.

10. AC AND Ω FUNCTIONS (A203, A223).

Set up as in Section C.

11. REMOTE

Plug in an A204 Fan Out Unit.

Check that the instrument functions normally.

11.1 Switch to REMOTE.

Check that the REMOTE signal is illuminated.

11.2 Check that the instrument will not operate on any of the front panel controls except MANUAL sample, 10/SEC and POWER.

11.3 Connect the testgear TG1022/17 to the fan out socket, (if available, see APPENDIX).

Check that the instrument samples with contact sample, (or that it samples when pin s is connected to pin HH (0V).

11.4 Switch to REMOTE on TG1022/17, (or connect pin r to pin HH (0V).

Check that this operation disables all front panel controls except POWER.

Operate sample on TG1022/17 and check that the instrument samples, (or apply a Pulse Sample Command, positive pulse of amplitude between 3 and 8V and greater than 10μs wide) to pin t.

11.5 Switch to LOCAL and 10mV range on TG1022/17, (or command the 10mV as per the Operating Manual, and disconnect pin r from pin HH.)

Switch to 10/SEC. on the front panel.

Apply 10mV to the input.

Check that the instrument reads 10mV on the 10mV range.

Repeat on each range with an appropriate input, (or command each range as per the Operating Manual).

11.6 Switch to AUTO on TG1022/17. (A200/A203 only , or command AUTO as per the Operating Manual).

Apply 18mV to input.

Check that the instrument reads 18mV on the 10mV range.

Increase the input to more than 19mV. (19000 digits).

Check that the instrument changes range to 100mV.

Reduce the input to less than 18mV. (1800 digits).

Check that the instrument changes range to 10mV.

11.7 Switch to AC mode on TG1022/17, (A203/A223 only , or command AC as per the Operating Manual).

Check that the AC sign appears. Switch to each range in succession and check that the correct ranges are called, (or command each range as per the Operating Manual).

11.8 Repeat for the Ω mode.

11.9 *Filter Settling Time, DC*

Switch OFF. Connect the test gear TG1022/19 (see APPENDIX) to the FAN OUT socket.

D.C. TEST.

Switch to DC, 10V range, Manual, SLOW filter. Switch ON.

Switch the test gear to 'RESPONSE' 1 SEC. TEST switch UP. Connect the DVM to the output of the test gear Apply an input of 10.000V dc to the input of the test gear. Switch to TEST on test gear and check the reading is within ± 1 digit.

12. SERIES MODE REJECTION. COMMON MODE REJECTION. OVERLOAD

These tests are carried out using test Gear TG1022/18 (See APPENDIX). Use an EX3193 (3 terminal Input Connector) for LOW to GUARD leakage. Information on TG1022/18:

a) A switch to select three different AC signal ranges giving an FSD of 100mV, 5V, 100V r.m.s. This signal is indicated on the AC meter.

b) A variac to vary the AC signal on the above ranges.

c) A Pot. to vary the DC output signal from 0 to 500V FSD. This signal appears on the output terminals on the DC common mode, DC LO to GU Leakage and overload checks only.

d) A Pot. to vary the DC signal from a battery. This is used in series and AC common mode checks only.

e) A push button to check the battery voltage. This voltage is indicated on the DC meter (20V FSD).

f) A toggle switch to measure the current drawn by DVM on overload checks, when switched to mA the reading is indicated on the DC meter. On 500V the DC meter indicates the DC output voltage.

g) A switch to select the different tests to be done.

Figs. 8.1 to 8.3 show the basic test equipment, without external phase shift.
In this case SLOW response should be selected.

On overload checks, the test gear is connected as a voltage source. The output is varied by DC Variac 1. Alternatively the COHU 351 may be used.

Set the test gear TG1022/18 as follows:

Volts-current switch to volts.
DC high voltage pot fully anticlockwise
AC signal variac fully anticlockwise.

12.1 Series mode rejection:

a) Switch the DVM to DC, 10V range, 10/Sec, FAST filter.

Switch the test gear to 'Series Mode Rejection,' AC signal range to 5V on T.G. (100mV range on TG for A220 and A223) and also 90^{O} phase shift.

Switch ON both test gear and DVM.

Adjust DC signal pots "C" and "F" to obtain 10/1 digits.
Increase the AC signal until the indicated reading changes by 1 digit.
The reading on the AC meter should be greater than 2.3V r.m.s. (70mV for A220 and A223).
Reduce the AC signal to zero.

b) Switch to 10V range on DVM, and SLOW filter.
Switch the AC signal range to 100V (5V range for A/220 and A223 on test gear) also 0^{O} phase shift.

Adjust the DC signal pots "C" and "F" to obtain 10/1 digits.
Increase the AC signal until the indicated reading changes by 1 digit.
The reading on the AC meter should be greater than 70V r.m.s. (2.3V for A/220)
Reduce the AC signal to zero.
See fig. 8.1 for basic test.

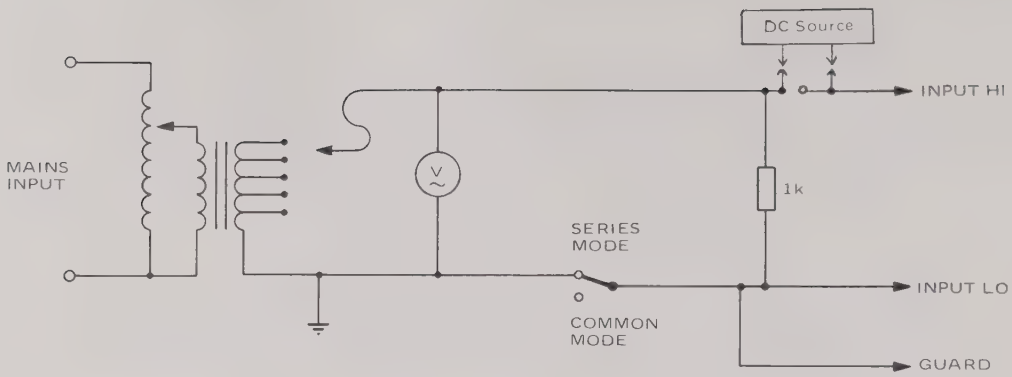


Fig. 8.1

12.2 AC common mode rejection.

a) Switch the test gear to "AC Common Mode Rejection" and the AC signal to 100V range.
Switch to 100mV range, FAST filter on DVM.

Adjust the DC signal pots "C" and "F" obtain 10/1 digits. Increase the AC signal until the indicated reading changes by 1 digit. The reading on the AC meter should be greater than 70V r.m.s. (1.5V for A/220).
Reduce the AC signal to zero.

b) Switch to AC mode, 1V range, SLOW filter on DVM.
Increase the AC signal to 100V rms.
The reading on the DVM should be less than 1,000 digits.
Reduce the AC signal to zero.
See Fig. 8.1 for basic test.

12.3 DC common mode leakage.

a) Switch to DC mode 100mV range SLOW filter on DVM.
Switch to 'HI/GND LEAKAGE' on the test gear. Increase the DC (VARIAC 1) pot to obtain 500V on DC meter. The displayed reading on the DVM should not exceed 56mV
Reduce the DC signal to zero.
See Fig. 8.2 for basic test.

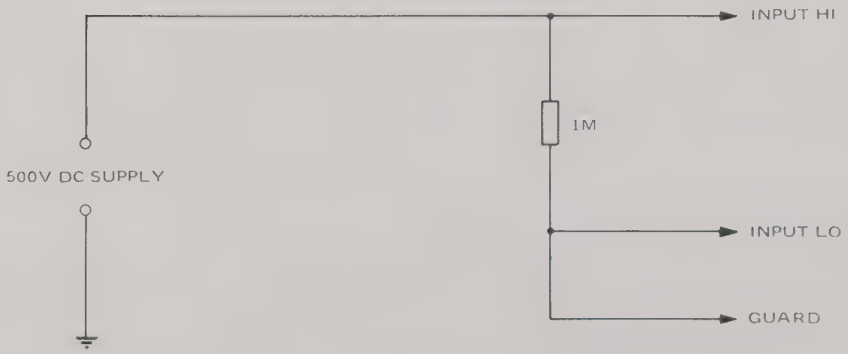


Fig. 8.2

(b) Switch to AC, 100mV range Slow filter on DVM.
Increase the DC (Variac 1) pot to obtain 500V on DC meter. The displayed reading on the DVM should not exceed 50mV.
Reduce the DC signal to zero.

12.4 LO to GUARD leakage.
Connect an EX 3193 in place of the standard input lead.
Switch to DC, 1V range SLOW filter on DVM.
Switch to "LO/GND LEAKAGE" on the test gear. Increase the DC (VARIAC 1) to obtain 500V on DC meter. The displayed reading on the DVM should not exceed 200mV. Reduce the DC signal to zero.
See Fig. 8.3 for basic test.

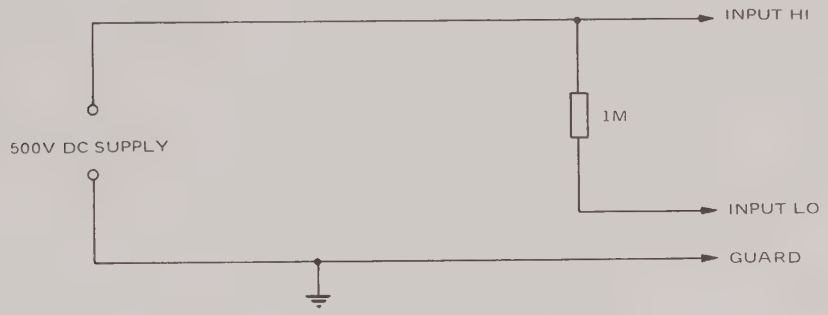


Fig. 8.3

12.5 Overload checks.
Alternatively, use COHU 351 as a DC source.

(a) Switch to 10mV range on DVM (100mV on A220 and A223).
Switch to "+ve O/L" on test gear. Increase the DC (Variac 1) to obtain 250V on DC meter. Check that the instrument reads +19999 and overload neon strikes (do not overload for more than 5 seconds).
Reduce the DC signal to zero.
Check that the instrument recovers from overload.

(b) Switch to "-ve O/L" on test gear and repeat(a)

12.6 High Voltage On Auto Range.
Alternatively, use COHU 351 as a DC source.

Switch to AUTO range and check that the instrument reads on 10mV range.
Switch to manual sample.
Increase the DC signal to obtain 500V on DC meter. Take sample and check that the displayed reading is 500V.
Reduce the DC signal to zero and take a sample.
Check that the instrument reads on 100mV range.

13. TEMPERATURE CHECKS

Switch ON and allow the instrument to stabilise for 90 minutes in ambient temperature (25°C approx.).
Set the μV OFFSET pot. as in 6.4, and the references (+ and -) as in 5.3.

Check that the input current reading is less than 20μV as in 4.4

Place the instrument in an oven at 50°C and allow it to stabilise for more than 2 hours.

Check that the input current reading is less than 100 digits.

Check that the zero input reading is not more than 5 digits ±1 (i.e. ± 0.2μV/°C x 25).

Reset the μV OFFSET pot.

Check the basic functioning of the instrument.

Apply a 18.000V input on the 10V range.

Check that the new reading is 18.000V ± 6 digits.

Check the reading on opposite polarity.

Check the reading on all basic ranges.

Check that the zero output reading on AC is not more than 6 digits

Check that the zero output reading on Ω for all except the 10MΩ range is not more than 2 digits.

Check that the zero input reading on Ω for the 10MΩ range is not more than 6 digits.

Remove the instrument from the oven, and allow to cool for at least 2 hours.

Check the + and - reference on the 10V range as per 5.3.

Check zero input reading as in 5.6.

Check the basic functioning.

B. DC FINAL CALIBRATION

Note: The instrument should have been operated for at least 48 hours at ambient temperature before final calibration at 20°C.

The instrument should be switched ON at least 1 hour before calibration.

Short circuit the input leads.

Check that the DVM reads zero on all ranges.

DC STANDARDS
TEST EQUIPMENT

DC potentiometer, 0.001%	e.g. Cambridge Type 44248
Temperature Controlled Standard Cell Bank	e.g. Guildline 9152T/4
Volts Ratio Box, 0.001%	e.g. Sullivan T2100
DC Voltage Standard, 0.003%	e.g. COHU 351

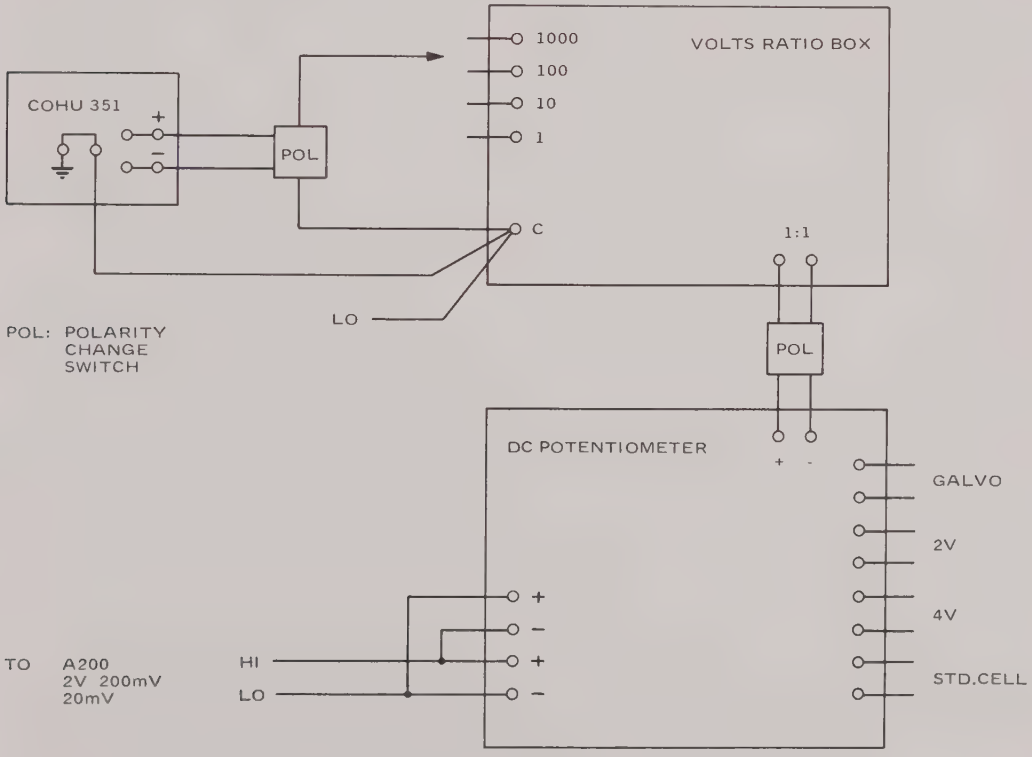


Fig. 8.4

The test equipment interconnection is shown in Fig. 8.4.

The equipment must be thoroughly stabilised at 20°C ± 1°C and must be operated, maintained and records kept in accordance with Standards Room Procedures.

The Volts Ratio Box and Standard Cell Bank should have valid certificates of calibration and values traceable to a National Calibration Authority.

The instrument should have been switched on for at least two hours in a 20°C (± 1°C) ambient, stable to 0.5°C.

1.1 A200/A203 only.

Switch to the 10mV range, DC FAST filter and 10/SEC.

Check that the noise scatter is less than 2μV (4 digits).

Switch to SLOW filter.

Check that the noise scatter is less than 1μV (3 digits).

1.2 Switch to the 10mV range (100mV on A220/A223) and SLOW filter.

A200, A203: Check that the μV OFFSET pot. covers more than 10 bits either side of zero.
A220, A223: Check that the μV OFFSET pot. covers more than 50 bits either side of zero.

Reset the μV OFFSET pot.

Check the zero reading on all ranges with FAST and SLOW filter.

1.3 Switch to 10V range and FAST filter.

Apply an input of +18.0005V and adjust RV5 (+ ref.) on pcb 3 to obtain +18.000/1 (See Drg. 5).

Reverse the polarity of the input and adjust RV4 (-ref.) on pcb 3 to obtain - 18.000/1 (see Drg. 5).

1.4 Check the linearity on the 10V range in 10% steps, using the RV622A (10kΩ) Dekavider and the COHU 351. Tolerance: ±1 digit.

1.5 Apply the inputs detailed and check each range as follows:

Range	Filter	Input	Adjust		pcb	Drawing	Reading	Limits
*10mV	SLOW	+18.000mV	(10mV)	RV3	26	5	+18.000	2
*10mV	SLOW	- 18.000mV	(10mV)				- 18.000	2
*10mV	FAST	+18.000mV					+18.000	4
*10mV	FAST	- 18.000mV					- 18.000	4
100mV	FAST	+180.00mV	(100mV)	RV2	26	5	+180.00	1
100mV	FAST	- 180.00mV					- 180.00	1
1V	FAST	+1.8000V	(1V)	RV1	26	5	+1.8000	1
1V	FAST	- 1.8000V					- 1.8000	1
100V	FAST	+180.00V	(ATTN.)	RV1	6	1 & 2	+180.00	1
100V	FAST	- 180.00V					- 180.00	1
1000V	FAST	+1100.0V				1 & 2	+1100.0	1
1000V	FAST	- 1100.0V					- 1100.0	1

*A200/A203 only

1.6 Check the linearity on the lowest range in 10% steps, using the Cambridge 44248, or the Dekavider RV622A and COHU 351. Tolerance: ±1 digit.

C. AC AND Ω FINAL CALIBRATION (A203 AND A223 ONLY)

The instrument should be switched on at least 1 hour before calibration.

Switch to DC and check the instrument reads zero on all ranges. If necessary adjust the μV OFFSET pot. on the lowest range with slow filter.

1. Ω MODE

1.1 Switch to OHM mode, 10/SEC, FAST filter and the 1kΩ range.

Short circuit the input leads.

Adjust RV1 pcb 16 to obtain a zero reading. If zero cannot be obtained cut link 2 on pcb 16, and repeat, (see Drg. 4).

Check that the instrument reads zero on all ranges. (10mV DC range is the same as 1kΩ).

If necessary, adjust C5 on pcb 5 on the 1MΩ and 10MΩ ranges to obtain zero (see Drg. 17).

1.2 Switch to the 100kΩ range.

Connect a known resistor of value 180k to the input.

Adjust RV4 on pcb 26 to obtain a reading 180.00kΩ, (see Drg. 5).

Switch to 1MΩ range.

Connect a 1.8MΩ known tolerance resistor and check that the reading is 1.8000 ± 10 digits.

1.3 Switch to the 10kΩ range.

Apply a known resistor of value 18kΩ to the input.

Adjust RV3 pcb 15 to obtain a reading of 18.000kΩ, (see Drg. 4).

Using the RS624A check the linearity in 10% steps. Tolerance: ±1 digit.

Switch to the 1kΩ range.

Connect a 1.8kΩ known tolerance resistor and check that the reading is 1.8000 ± 10 digits.

1.4 Switch to the 10MΩ range.

Check the linearity by applying suitable inputs. Tolerance: 0.5% of reading of ±6 digits.

1.5 A203 only.

By applying suitable inputs check AUTO ranging.

2. AC MODE

2.1 Switch to AC mode and 100mV range.

Short circuit the input leads.

Adjust RV3 pcb 14 to obtain minimum reading, (see Drg.3 "Set AC LIN").

Check that the instrument reads zero ± 6 digits on all ranges.

2.2 Switch to the 1V range.

Apply an input of 1.8V rms at 1kHz.

Adjust RV2 pcb 14 to obtain a reading of 1.8000V.

Check the reading at 100Hz, 10kHz, 20kHz. C7 selected in test (68pf ,82pf or 100pf)
Tolerance: ± 10 digits.

Check the reading at 50kHz, 100kHz. Tolerance: ± 180 digits.

Check the reading at 20Hz with SLOW filter. Tolerance ± 180 digits.

Apply 0.1V rms at 1kHz and reset RV3 pcb 14 to obtain 0.1000V, (see Drg.3, "Set AC LIN")

Check the linearity at 1kHz in 10% steps (using HP745A). Tolerance: ± 6 digits.

2.3 Switch to the 100mV range.

Apply an input of 180mV rms at 1kHz.

Adjust RV1 pcb 14 to obtain a reading of 180.00mV, (see Drg. 3).

Check the frequency response. Tolerance: 40Hz to 20kHz, ± 10 digits
20Hz to 100kHz, ± 180 digits.

Use SLOW filter below 100Hz.

Check the linearity at 1kHz. Tolerance: ±6 digits.

2.4 Switch to the 10V range.

Apply an input of 18V rms at 1kHz.

Adjust RV1 pcb 15 to obtain 18.000V, (see Drg. 3)

Switch to 100V range.

Apply an input of 180V rms at 1kHz.

Check that the reading is 180.00 ± 18 digits.

2.5 Switch to the 1000V range.

Apply an input of 800V rms at 400Hz.

Adjust RV2 pcb 15 to obtain a reading of 800.0V (see Drg. 3).

2.6 Switch to the 10V range.

Apply an input of 18V rms at 20kHz.

Adjust C6 pcb 15 to obtain a reading of 18,000 ± 18 digits (see Drg. 3).

Check the frequency response of the 10V and 100V ranges as per 2.3.

2.7 Switch to the 1000V range.

Apply an input of 800V rms at 20kHz.

Adjust C7 pcb 15 to obtain a reading of 800 ± 10 digits (see Drg. 3).

Check the frequency response, (limits as in 2.3. Take special care at high frequencies).

Tolerance: 40Hz to 20kHz, ± 10 digits
20Hz to 100kHz, ± 80 digits.

2.8 Switch to the 1V range and SLOW filter.

Apply an input of 1V rms at 1kHz via a 10kΩ resistor. and then direct.

Check that the change in reading is not more than 13 digits.

2.9 *Filter Settling Time, AC*

Switch off. Connect TG 1022/19 (See Appendix) to the FAN OUT socket (A200 9127 on pcb 13).

Switch DVM to AC, 1V range, FAST filter.

Apply an AC input to test gear, with the TEST switch UP (1.8V).

Switch to TEST. Check the reading when staticised.

Switch to NORMAL and 10/SEC. on DVM.

Check that the difference in reading does not exceed 18 digits for an input of 1.8000V rms.

Short circuit the input to the test gear.

Switch the DVM to MANUAL, SLOW filter.

Switch the test gear to RESPONSE, 3 sec. and TEST switch UP.

Apply an input of 1.8000V to the input of test gear.

Switch to test. Note the reading when staticised after 3 secs.

Switch to NORMAL and 10/SEC. on DVM.

Check that the difference does not exceed 18 digits.

D. Testing The A204 FAN OUT Unit.

FAN OUT TEST EQUIPMENT

A203 Digital Voltmeter, (Solartron)

Voltage divider e.g. Sullivan 512 or ESI RV622A

Oscilloscope, from dc to 10MHz e.g. Solartron A100

Power Supply Unit, 1% Grade 0-10V dc in 0.1V steps, e.g. Solartron AS 1410.2

Pulse Generator, up to 200kHz, 20ns rise time 10μs pulse width and up to 10V amplitude e.g. Solartron GO 1101.2

In the following checks, Input and Output levels are checked on applied, as follows:

	Inputs	**Outputs**
High or '1'	+2.4V to +6V at 100μA or open circuit.	+2.4V to +6V from a 6KΩ source.
Low or '0'	- 0.5V to +0.5V at 5mA sink current.	-0.5V to +6V at 10mA sink current.

Plug the Fan Out Unit into the dvm edge connector socket A2009127 on pcb 13 (Earthy Mother Board).

Remove the blanking plate on the rear panel and secure the Fan Out socket SKA to the dvm rear panel using the blanking plate screws.

Output Checks

1. RANGE

Select DC, LOCAL, 10/SEC, FAST filter.

Select each range in turn.

With the oscilloscope on dc,2V/cm and signal low connected to pin **HH** of the Fan Out Socket, check the output at pins **j**,**h** and **f** conform to the following tables.

1.1 **Code 1** (Pins A and C linked on pcb A2049027)

Volts Range	j	h	f	Ohms Range
1000V	0	0	0	10MΩ
100V	0	0	1	1MΩ
10V	0	1	0	100kΩ
1V	0	1	1	10kΩ
100mV	1	0	0	1kΩ
10mV (DC only)	1	0	1	

1.2 **Code 2** (B to A linked and normally supplied)

Volts Range	j	h	f
1000V	0	0	1
100V	0	1	0
10V	0	1	1
1V	1	0	0
100mV	1	0	1
10mV	1	1	0

1.3 **Code 2**

Ohms Range	j	h	f
10MΩ	0	0	0
1MΩ	0	0	1
100KΩ	0	1	0
10KΩ	0	1	1
1KΩ	1	0	0

2. MODE

Using the oscilloscope as in 1., select DC AC and Ω in turn, checking pins **CC** and **DD** as follows.

2.1

Mode	CC	DD
DC	1	1
AC	0	1
Ω	1	0

3. STATICISED DISPLAY

Select DC.

Using the P.S.U. applied to the dvm signal input, check the output, using the oscilloscope set to dc and 1V/cm, at the pins detailed in 3.1 to 3.5.

3.1 **Range**

Range	Applied Volts	Pins			
		A	B	C	D
1000V	0	0	0	0	0
	0.1	1	0	0	0
	0.2	0	1	0	0
	0.3	1	1	0	0
	0.4	0	0	1	0
	0.5	1	0	1	0
	0.6	0	1	1	0
	0.7	1	1	1	0
	0.8	0	0	0	1
	0.9	1	0	0	1

3.2 Range 1000V

Applied Volts	Pins			
	E	F	H	J
0	0	0	0	0
1V	1	0	0	0
to	as per 3.1			
9V	1	0	0	1

3.3 Range 100V

Applied Volts	Pins			
	K	L	M	N
0	0	0	0	0
1V	1	0	0	0
to	as per 3.1			
9V	1	0	0	1

3.4 Range 10V

Applied Volts	Pins			
	P	R	S	T
0	0	0	0	0
1V	1	0	0	0
to	as per 3.1			
9V	1	0	0	1

3.5 Range 1V

Applied Volts	Pin
	U
0	0
1V	1

4. POLARITY

Using the P.S.U. and oscilloscope as in 3., apply an input on each polarity and check the outputs at Pins **d** and **e**.

4.1 Polarity

	Pins	
	d	e
Positive (+)	1	0
Negative (-)	0	1

5. OVERLOAD

Using the P.S.U. and oscilloscope as in 3, select 1V range.

5.1 Set the P.S.U. to 1.9V and adjust the mv pot. so that overload can be applied and removed.

5.2 Check pin **c** is at '1' on overload and at '0' when overload is removed.

6. PRINT COMMAND and DATA CAN CHANGE

Using the P.S.U. and oscilloscope as in 3 check the following outputs.

6.1 **'Level'**

Rate	Pin x	Pin v	
10/SEC	1	0	
MANUAL	**0 pulse**	**1 pulse**	for approx. 19ms during DRIFT CORRECT

See FAN OUT SHEETS 1 & 2 with waveforms.

6.2 **'Pulse'** Select MANUAL

Pin u

1 pulse of approximately 10μs
8μs after End of Ramp Down.

7. GATED CLOCK

Set the oscilloscope to 1V/cm and 2μs/cm

7.1 Check that the clock pulses at pin **k** correspond to the data displayed.

7.2 E.G. obtain a dvm display of 5 digits using the PSU and Voltage divider.

Note that 5 clock pulses are present.

7.3 Increase the dvm display to 6 digits.

Note that 6 clock pulses are present.

See FAN OUT Sheets 1 & 2 with waveforms.

Input Checks
(Remote Commands)

8. CONTROL

8.1 Select REMOTE on the dvm.
Check that the REMOTE Signal is illuminated.

8.2 Check that the dvm will not operate on any of the front panel controls except MANUAL sample, 10/SEC and POWER.

8.3 Command REMOTE externally (using TG 1022/17 or by connecting pin **r** to **HH**).

Check that this operation disables all front panel controls except POWER, and note the dvm is in the 1000V range.

9. CONTROL (CONTACT) SAMPLE

Using the P.S.U set to 1.8V carry out the following checks.

9.1 Set the dvm display to zero (if necessary, short circuit the input leads, cancel REMOTE externally and select 10/SEC for a zero reading. Command REMOTE externally as in 8.3).

9.2 Apply 1.8V to the dvm input.

Check that the dvm samples (displays a reading) when contact sample is operated (using the TG 1022/17 or by connecting pin s to pin **HH**).

10. PULSE SAMPLE

Switch on the Pulse Generator and set one shot, 3.2V amplitude and 12μs pulse width

10.1 Set the dvm display to zero by repeating 9.1.

10.2 Apply 1.8V to the dvm input.

Apply the pulse generator +ve output to pin t via the generator coaxial lead

Press the one shot button on the generator, and check that the dvm samples (alternatively command pulse sample on the TG 1022/17).

11. RANGE

Cancel REMOTE externally (using TG 1002/17 or by disconnecting pin r from pin **HH**).

Select 10/SEC on the dvm front panel, ensuring that REMOTE remains selected on the front panel.

11.1 Command the following ranges (using TG 1022/17 or by connecting pins **p**, **n** and **m** to pin **HH** where '0' is indicated), checking that each range is correctly displayed.

Voltage Range	p	n	m
1000V	0	0	0
100V	0	0	1
10V	0	1	0
1V	0	1	1
100mV	1	0	0
10mV	1	0	1

12. MODE

12.1 Command the following modes (using TG 1022/17 or by connecting pins **AA** and **BB** to pin **HH** where '0' is indicated as follows, checking that each mode is correctly displayed

Mode	AA	BB
DC	1	1
AC	0	1
Ω	1	0

13. AUTO RANGE

Command Auto Range (using TG 1022/17 or by connecting pin **y** to pin **HH**).

13.1 Set 1V on the P.S.U. and apply this to the dvm input via the Voltage Divider.

13.2 Set the Voltage divider for an output of 18mV (0, 0, 1, 8) and check the dvm reads 18mV on the 10mV range.

13.3 Increase the input for a dvm reading of more than 19.000mV.
Check that the dvm changes to the 100mV range.
Reduce the input to less than 018.00mV.
Check the dvm changes to the 10mV range.
Disconnect pin **y** from pin **HH**.

14. RESPONSE

14.1 Command 1V range as in 11.1.

14.2 Command **SLOW** response (using TG 1022/17 or by connecting pin **z** to pin **HH**).

14.3 Short circuit the dvm input leads for a zero reading; select MANUAL on dvm front panel.

14.4 Apply approximately 1.8V to the dvm. Press the MANUAL button.

14.5 Note the dvm displays WAIT for approximately 1 second. The display then reads the applied voltage.

14.6 Cancel SLOW (on disconnect pin **z** from pin **HH**).

15. DATA HAS CHANGED

15.1 Set the oscilloscope to 2V/cm and 2ms/cm and connect signal Hi to pcb 28 pin 15.

15.2 Set the pulse generator as in 10. PULSE SAMPLE, connecting +ve output to pin **t**.

15.3 Triggering the oscilloscope from the Pulse Generator, apply PULSE SAMPLE (press one shot on the pulse generator).

Check that pcb 28 pin 15 goes Low after approximately 10ms.

15.4 Connect pin **w** to pin **HH** (i.e. setting Logic '0')
Apply PULSE SAMPLE as in 15.3 and check that pcb 28 pin 15 goes Low after approximately 1ms.

E. APPENDIX

Ancillary Test Equipment

1. FET NOISE SELECTION

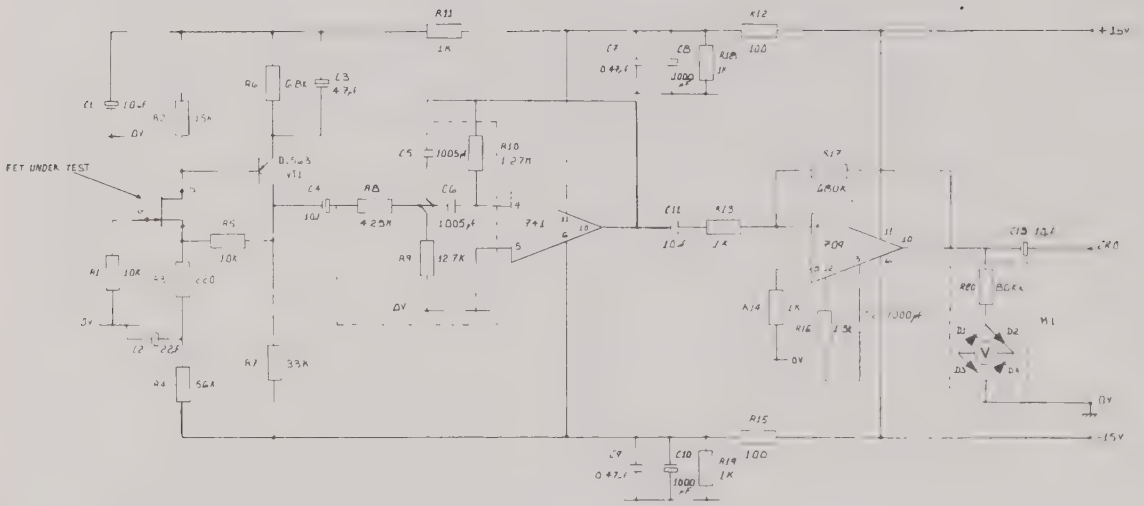


Fig. 8.5 T.G. 1030. TR1 and TR3 (A200, A203 Input amp.) pcb 2, Low Noise Selection.

Use Initial selection and replacement of TR1 and TR3 on pcb 2 (Input amp., A200 and A203 only).

See **Section 7, INPUT AMPLIFIER 6.**

Description

1) The power rails must be from a dc source set to + 15V and - 15V (± 0.5V) at 10ma load.

2) The circuit comprises a high gain narrow band amplifier.

The FET under test is biased to a point of prominent noise.

Noise is amplified by VT1 and fed to operational amp. IC SN72741 which has a frequency response of 2.45 kHz (± 300 Hz to -3db).

A second IC operational amp., SN72709, increases the circuit gain to 5×10^6

3) The meter, M1 (SIFAM, Solartron spec. no. 34003060) has a FSD of 5V r.m.s. and therefore indicates 1μV of FET noise at full scale.

From the C.R.O. socket, the noise may be seen on a display. This is less precise to read than the meter.

Noise Selection Test

1) Switch the power supplies ON.

2) Check the meter settles to within 0 + 0.05μV (FSD = 1μV).

3) Plug in the FET under test to the test socket.

4) Note the meter reading.

For a 2N 4303, $< 0.3\mu$V is an acceptable noise level.

TG 1030 Servicing Note

C5 and C6

If either one of these is changed both must be reselected to a matching tolerance of 0.5%.

2. REMOTE COMMANDS

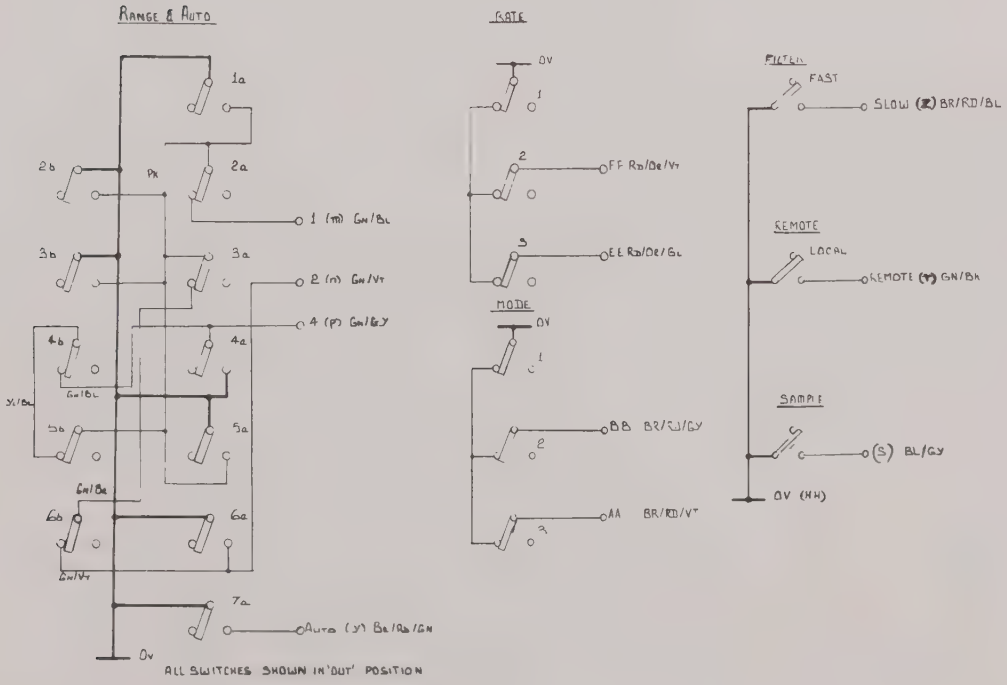


Fig. 8.6 TG 1022/17. Remote Commands

Use See Section 8. A paras. 11.6 to 11.8 and 8. D para.8.

TRUTH TABLES

Range	Switch	4	2	1	Auto
10MΩ 1000V	1	0	0	0	1
1MΩ 100V	2	0	0	1	1
100kΩ 10V	3	0	1	0	1
10kΩ 1V	4	0	1	1	1
1kΩ 100mV	5	1	0	0	1
- 10mV	6	1	0	1	1
Auto Auto	7				0

Mode	Switch	AA	BB
DC	1	1	1
AC	2	0	1
Ω	3	1	0

3. FILTER SETTLING TIME

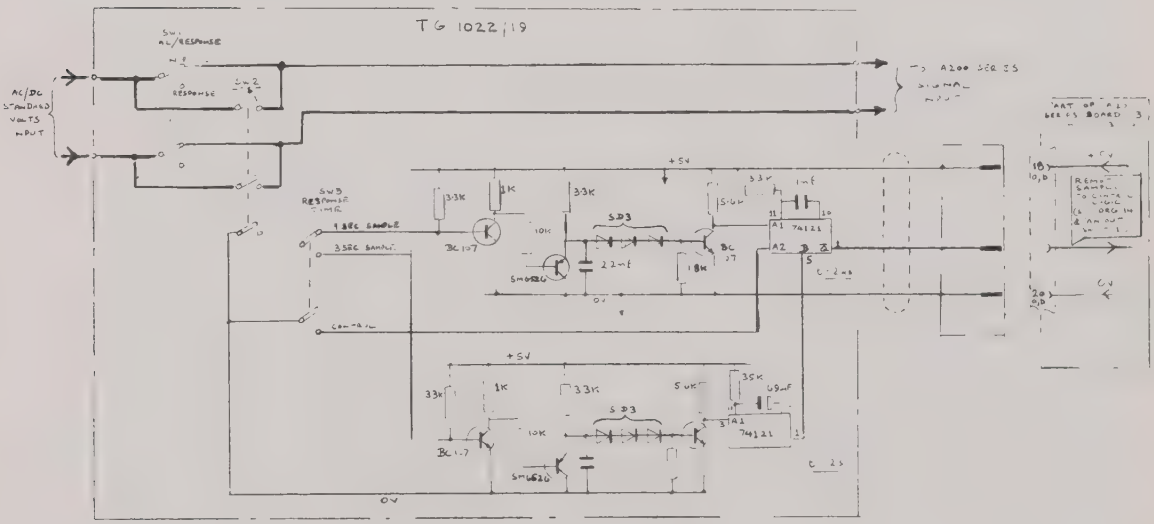


Fig. 8.7 TG 1022/19. Filter Settling Time

Use See Section 8.A para. 11.9 and 8.C para. 2.9

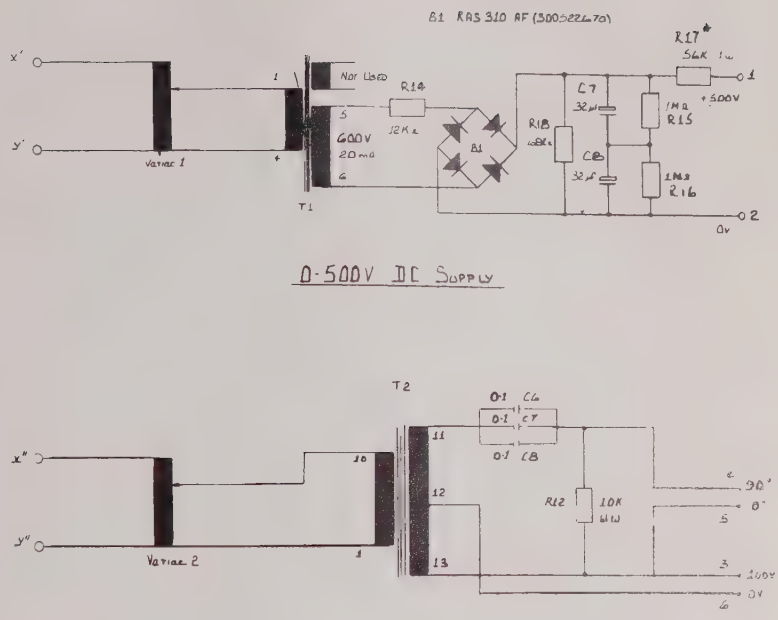


Fig. 8.8 (ii) TG 1022/18/02 DC and AC Supplies.

4. SERIES AND COMMON MODE REJECTION

Use See Section 8.A para 12

Notes

Fig. 8.8.(i) shows the Basic Unit

Fig. 8.8.(ii) shows:-

MAINS DISTRIBUTION
- L.T. P.S.U. + 18V dc for IC1, Fig. 8.8.(iii)
- H.T. P.S.U. 0 to + 500V dc
- A.C. P.S.U. 0 to 100V ac

Fig. 8.8.(iii) High Stab. DC Source.

O/P is at 10 (high) and 9 (low)
"A" and "B" are battery test points to DC Multimeter.

Fig. 8.8.(iv) DC Multimeter and AC Millivoltmeter.

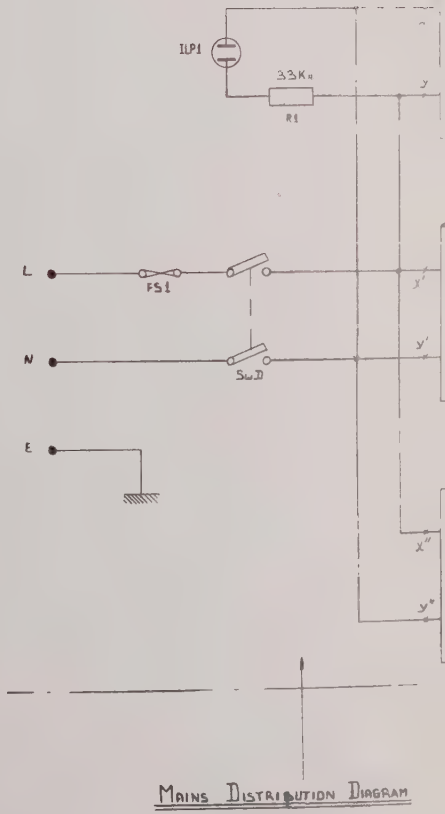
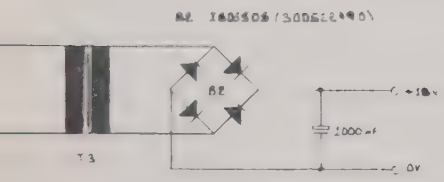
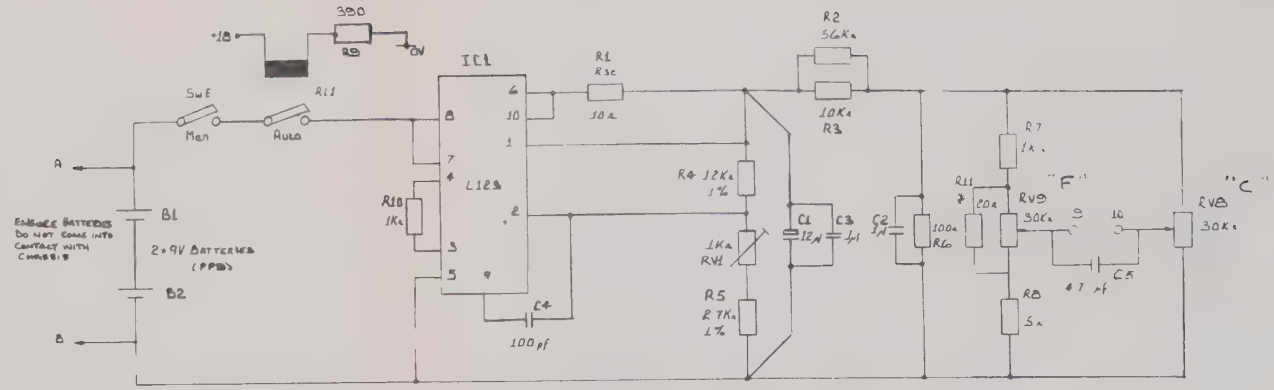


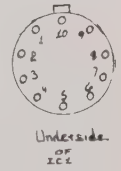
Fig. 8.8 (i) TG 1022/18/01 Series and Common Mode Test Bo



10V DC SUPPLY



1: I Sense
2: INV I/P
3: NON-INV I/P
4: V ref
5: -Vs
6: Vout
7: Va } Vin
8: +Vs }
9: f Comp.
10: I Limit



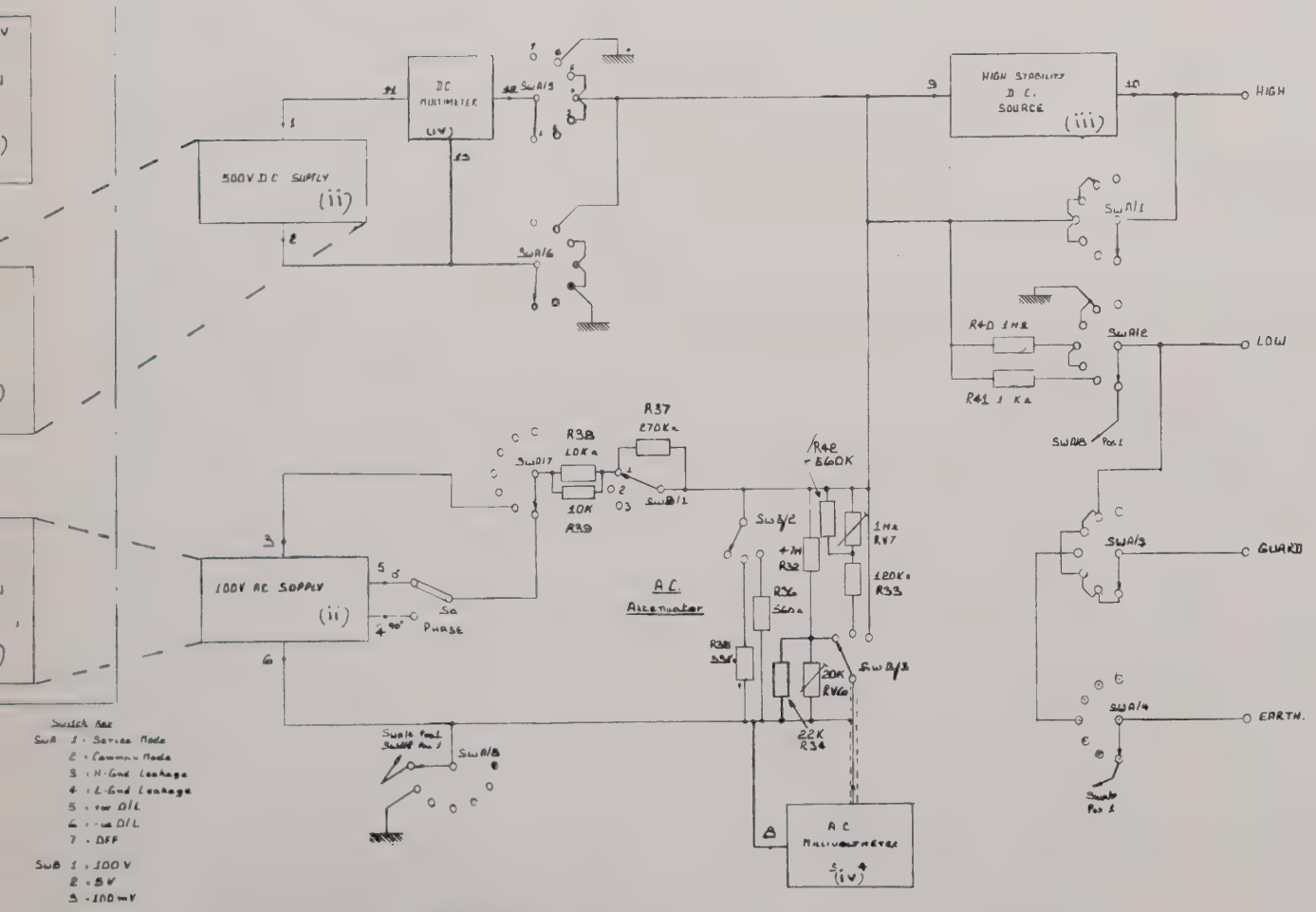
HIGH STAB. DC SOURCE.

* R11 Mounted on RV9

Note

R17 Mounted on Board 4

Fig. 8.8 (iii) TG 1022/18/03 High Stab. DC Source .



BASIC BLOCK DIAGRAM

NOTE: R39, R38, R37 } Mounted on SwB R40, R41 } on SwA

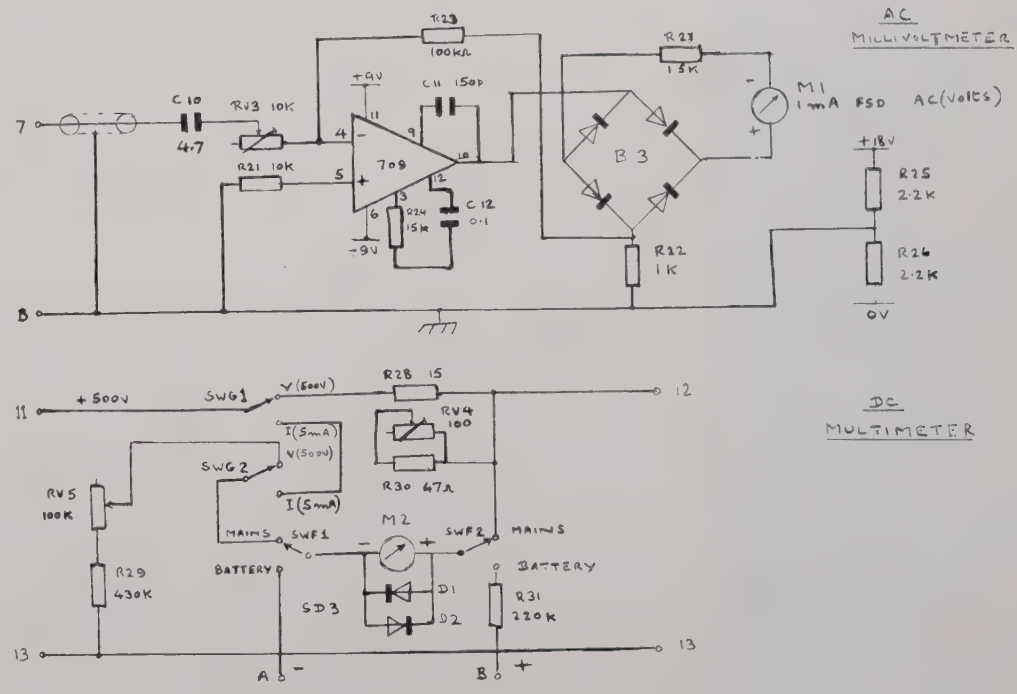
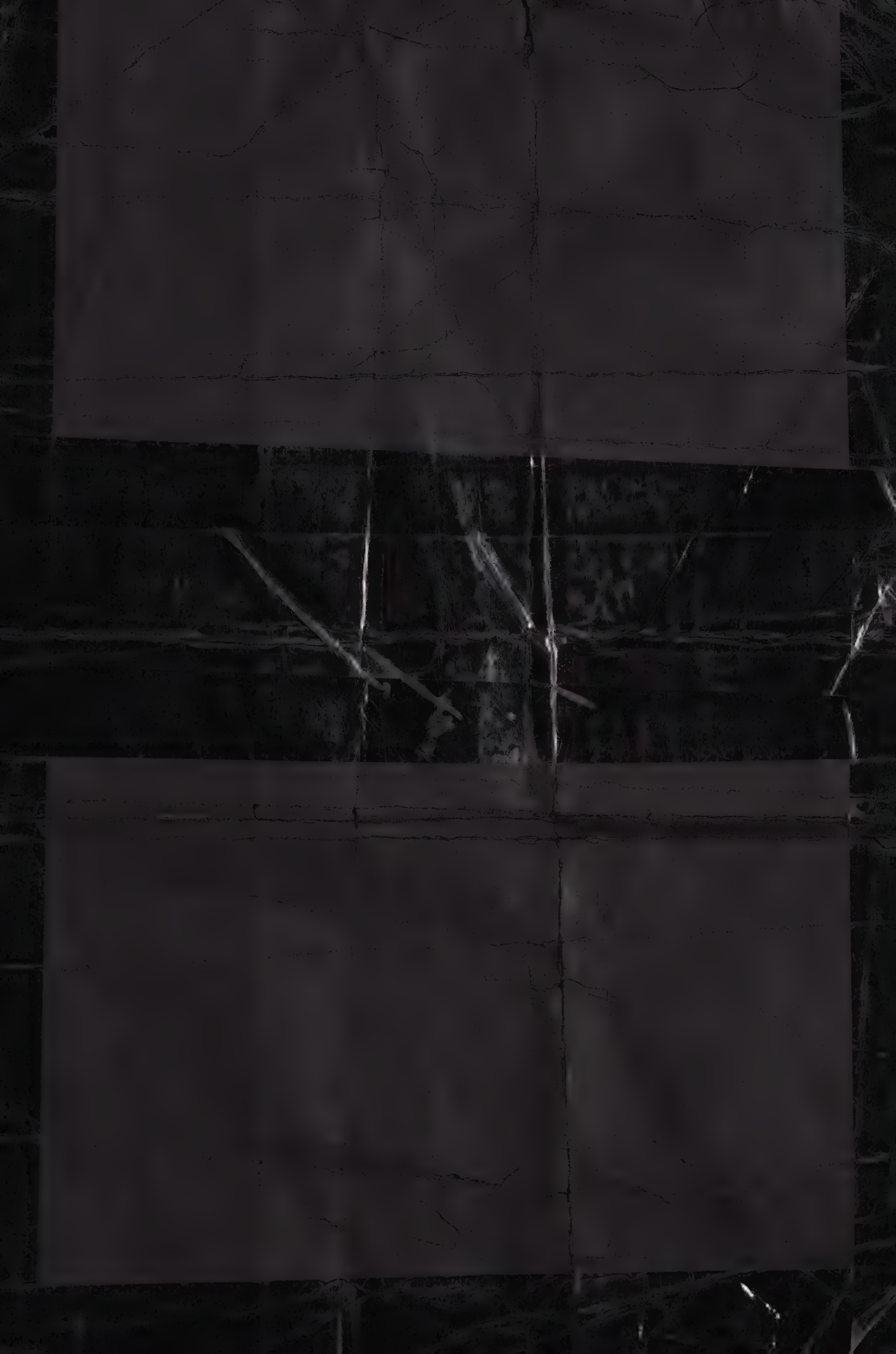


Fig. 8.8 (iv) TG 1022/18/04 DC Multimeter and AC Millivoltmeter.



F. DVM TYPES A205 AND A225

1. Carry out the initial calibration and set up the DC and 0HMS ranges as with DVM Types A203 for A205 or A223 for A225.

2. Ensure that the instrument has been switched on for at least 1 hour.

3. Switch to AC mode, Fast Response, 10 rdgs. per second, and 100mV range.

   With a short-circuited input lead, adjust RV2 on PCB 16 to obtain a reading of zero. Check that the instrument reads less than 2 bits on all other AC ranges.

4.a) Select the 1V range and, using a Hewlett-Packard 745a or similar instrument, apply an input of 20.00mV rms at 400Hz.

Adjust RV5 on PCB 41 (AC LINEARITY) to obtain a reading of 0.0200 Volts. Increase the input to 1.9000 Volts at 400Hz and adjust RV2 on PCB 41 (AC 1V) to obtain a reading of 1.9000 Volts.

b) Apply the inputs as shown in the table below, checking that the readings are within the specified limits.

TABLE 1

Voltage	Frequency	Allowable Error (bits)
1.9000V	10Hz	200 - Select slow filter for this reading.
1.9000V	40Hz	35
1.9000V	10kHz	35
1.9000V	60kHz	200
1.9000V	100kHz	200
1.0000V	400Hz	10
1.0000V	10kHz	25
1.0000V	100kHz	190
0.3000V	400Hz	10
0.3000V	10kHz	18
0.3000V	100kHz	180

0.1000V	400Hz	10
0.1000V	10kHz	15
0.1000V	100kHz	180
0.0100V	400Hz	10
0.0100V	10kHz	15

5.a) Select the 100mV range and apply an input of 190.00mV at 400Hz. Adjust RV1 on PCB 41 (AC 100mV) to obtain a reading of 190.00mV ± 0.02mV.

b) Apply inputs of 190.00mV at the frequencies shown in table 2 and check the readings are within the specified limits.

TABLE 2

Frequency	Allowable error (bits)
10Hz	200
40Hz	35
10kHz	35
60kHz	200
100kHz	200

6.a) Select 10V range and apply 19.000V at 400Hz adjust RV1 on PCB 15 (AC 10V/100V) to obtain a reading of 19.000V.

b) Apply 19.000V at 10kHz and adjust C6 on PCB 15 (AC 10V/100V HF) to give a reading of 19.000V ± 10 bits, and note this reading.

Select the 100V range and apply 190.00V at 10kHz. Re-adjust C6 on PCB 15 (AC 10V/100V HF) to share errors between 10V and 100V ranges at 10kHz.

Check the frequency response of both 10V and 100V ranges to within the limits shown in table 2 and provide minor re-adjustments of C6 if necessary.

7.a) Select 1000V range and apply 800.0V at 400Hz using a twisted pair type of input lead. Adjust RV2 on PCB 15 to give a reading of 800.0 Volts.

b) Increase the frequency to 20kHz and adjust C7 on PCB 15 to give a reading of 800.0 Volts.

Check the frequency response to within the limits shown in Table 2.

SECTION 9 Component Parts List

COMPONENT PARTS LIST

ABBREVIATIONS

Circuit References

B	Battery
C	Capacitor (μF)
CSR	Thyristor
D	Diode
FS	Fuse
IC	Integrated Circuit
L	Inductor
LP	Lamp (including Neon)
LK	Link
M	Meter
MSP	Mains Selector Panel
PL	Plug
R	Resistor (Ω)
RL	Relay
S	Switch
SK	Socket
T	Transformer
TP	Terminal Post (or Test Point)
TR	Transistor
V	Valve
X	Other Components

Also Used:-

RNL	Non Linear Resistor (Ω)
RV	Variable Resistor (Ω)

Component Composition

FIXED RESISTORS

Carbon Composition	CACP
Carbon Film	CAFM
Cracked Carbon	CKCA
Metal Film	MEFM
Metal Oxide	MEOX
Power Wirewound	POWW
Precision Wirewound	PRWW
Temperature Sensitive	TEMP
Thick Film	TKFM
Thin Film	TNFM
Voltage Sensitive	VOLT

Component Composition (Cont'd)

VARIABLE RESISTORS

Wirewound Preset Single Turn	WWPS
Wirewound Preset Multiturn	WWPM
Wirewound Front Panel Single Turn	WWFS
Wirewound Front Panel Multiturn	WWFM
Carbon Preset Single Turn	CAPS
Carbon Preset Multiturn	CAPM
Carbon Front Panel Single Turn	CAFS
Carbon Front Panel Multiturn	CAFM
Cermet Preset Single Turn	CMPS
Cermet Preset Multiturn	CMPM
Cermet Front Panel Single Turn	CMFS
Cermet Front Panel Multiturn	CMFM

CAPACITORS

Air	AIR
Aluminium Electrolytic	ALME
Aluminium Solid	ALMS
Polycarbonate	CARB
Ceramic	CERM
Polyester Foil	ESTF
Polyester Metallised	ESTM
Glass	GLAS
Mica	MICA
Metallised Lacquer	MLAC
Paper Foil	PAPF
Paper Metallised	PAPM
PTFE	PTFE
Polypropylene Film	PYLN
Polystyrene	STYR
Tantalum Dry	TAND
Tantalum Foil	TANF
Tantalum Wet	TANW

Component Parts List
for
Accessories
(MD A209)

General Description	Solartron Part No.
Input Lead Assy	ADA2000168
Clip, Alligator (Red)	355900670
Clip, Alligator (Black)	355900660
Prod. Test Black	351901010
Prod. Test Red	351901020
Fuse 750mA Slo-Blo*	360103070
Fuse 300mA Slo-Blo*	360103170
Lock Plate (Mains Selector Plate)	FDA2000145
Bag Self Sealing	810000210
Bag Self Sealing	810000140
Handle (Rack MTG)	429700101

* As indicated on Mains Selector Plates

Component Parts List
for
Main Frame
(MD A209)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	1M	¼W	10%	172361000
R2	CACP	1M	¼W	10%	172361000
R10	POWW	180	6W	5%	174321800
	Terminal Standoff (Ins.)				355400111
	Resistor Bkt. Fab				FDA2000113
C1	PAPM	0.047	630V	20%	208300059
C2	PAPM	0.047	630V	20%	208300059
TR1	Transistor 2N3055				300552340
	Mica Washer				300584050
	Transistor Cover				300584620
	Mains Lead				480140200
	Board Guide				A2000042
	Board Clamp				A2000048
	L.H. Side Panel				FDA2000034
	R.H. Side Panel				FDA2000032
	Nixie Housing				A2100020

Cct Ref.	General Description	Solartron Part No.
T1	Mains Transformer	3096002-05
	9-way Tagstrip	A2000115
SWJ	Switch Slider D.P.D.T.	375000100
SWK	Switch Slider D.P.D.T.	375000100
SWH	Mains D.P.S.T. Switch Push Button	377000290
	Extension Shaft	A2000139
	Red Knob	400001750
	Black Knob	400001720
	Escutcheon	420610050
F1	Fuse Holder	360202000
	Fuse Link 250mA Slo-Blo	360103050
	Fuse Link 300mA Slo-Blo*	360103170
	Cover Plate	A2000122
	Lock Plate (Mains Selector Plate)	FDA2000133
	* as indicated on Mains Selector Plates	

Component Parts List
for
Floating Box Assembly
(MD A209)

Cct Ref	General Description				Solartron Part No.
RV1	CAFS	4.7k	¼W	20%	136834700
C1	CERM	0.047	25V	+10% -20%	241944700
T2	Quad Toroid Block				309600605
	5-way Skt				352105010
	Housing Fab				FD16370002
	Coil				301200101
	End Cap				16370007
	Core Rod				16370008
	Spire Fastener				412006570
	Extension Spindle				A2000179
	P.T.F.E. Stand Off				355400590

Quad Toroid Block T2 Sub Assembly

Cct Ref.	General Description			Solartron Part No.
R1 to R3	CACP	1k	1/8W	172031000
R4	CACP	10k	1/8W	172041000
R5	CACP	100Ω	1/8W	172021000
C1 to C3	CERM	470p	500V	241324700

Cct. Ref.	General Description				Solartron Part No.
R6	CACP	1M	1/8W	10%	172061000
R7	CACP	2.2k	1/8W	10%	172032200
R8	MEOX	47k	1/2W	5%	193544700
R9	MEOX	68k	1/2W	5%	193546800
R10	MEOX	150k	1/2W	5%	193551500
R11	MEOX	100k	1/2W	5%	193551000
R12	MEOX	120k	1/2W	5%	193551200
R13	CACP	2.2k	1/8W	10%	172032200
R14	MEOX	120k	1/2W	5%	193551200
R15	MEOX	120k	1/2W	5%	193551200
R16	MEOX	100k	1/2W	5%	193551000
R17	MEOX	120k	1/2W	5%	193551200
D1	Zener	39V	1W		300525480
X1	SP354				300730290
X2	SP353				300730280
LP1 to LP7	NS509/1				300720450
SK1	Edge Connector				352544090

Component Parts List

for

Printed Circuit Board A2009047

(Display Driver)

Cct Ref.	General Description				Solartron Part No.
R1	MEOX	68k	1/2W	5%	193546800
R2	CACP	220	1/8W	10%	172022200
R3	CACP	3.3k	1/8W	10%	172033300
R4	CACP	4.7k	1/8W	10%	172034700
R5	CACP	4.7k	1/8W	10%	172034700
R6	CACP	3.3k	1/8W	10%	172033300
R7	CACP	4.7k	1/8W	10%	172034700
R8	CACP	4.7k	1/8W	10%	172034700
R9 to R12	MEOX	12k	1/4W	5%	195641200
R13 to R16	CACP	3.3k	1/8W	10%	172033300
R17 to R20	CACP	470k	1/8W	10%	172054700
R21 to R24	CACP	4.7k	1/8W	10%	172034700
D1	Zener	2.7V			300523870
D2 to D10	IS 921				300522620
TR1 to TR4	40327				300552890
TR5 to TR7	A1778				300551430
TR8 to TR10	40327				300552890
TR11 to TR14	A1778				300551430
IC1 to IC4	Decoder/Driver Sperry				510001600
V1	Neon Lamp 16H				300720220

Cct Ref.	General Description	Solartron Part No.
D1 to D4	Diode SD3	300522160
TR1	SM6526	300552990
TR2	BC107/S	300553320
TR3	BC107/S	300553320
IC1	SN74121N	510000530
IC2	SN7470N	510000750
IC3	SN15836N	510000290
IC4	SN7400N	510000340
IC5	SN158093N	510000300
IC6	SN7474N	510000490
IC7	SN7474N	510000490
IC8	SN7413N	510000710

Component Parts List

for

Printed Circuit Board A2009031

(Link Board, A200 and A220)

Cct Ref.	General Description				Solartron Part No.
R1	MEFM	1k	1/8W	1%	192731002

Component Parts List

for

Printed Circuit Board A2009034

(Floating Power Supply Transformer)

Cct Ref.	General Description				Solartron Part No.
C5	GLAS	2-12pF	2.5kV		290060030
C14	STYR	6.8pF	500V	½pF	208100087
C15	STYR	6.8pF	500V	½pF	208100087
C17	GLAS	2-12p	2.5kV		290060030
T1	Transformer Inv.				309600401

Component Parts List

for

Printed Circuit Board A2009036

(Toroid Driver & Receiver)

Cct Ref.	General Description				Solartron Part No.
R1 to R5	CACP	1k	1/8W	10%	172031000
C1	CERM	0.047	25V	+50% -25%	241944700
C2 to C4	CERM	3300	500V	20%	241333300
D1 to D8	Diode SD3				300522160

Component Parts List

for

Printed Circuit Board A2009041

(R.M.S. Converter)

Cct Ref.	General Description				Solartron Part No.
R1	CKCA	10M	1/2W	5%	170871000
R2	CACP	100k	1/8W	10%	172051000
R3	MEFM	10k	1/8W	1%	191241002
R4	CACP	10k	1/8W	10%	172041000
R5	MEFM	10k	1/8W	1%	191241002
R7	Attenuator	1.179k	1/10W	0.1%	169607101
R8	Attenuator	131	1/10W	0.1%	169607101
R9	MEFM	4.7	1/8W	1%	191204702
R11	MEOX	33	1W	5%	193413300
R12	MEOX	33	1W	5%	193413300
R13	Attenuator	50k	1/10W	0.1%	169607101
R16	CACP	10M	1/2W	10%	172371000
R17	CACP	47k	1/8W	10%	172044700
R18	MEFM	10	1/8W	1%	191211003
R19	CACP	10k	1/8W	10%	172041000
C1	ESTM	0.033	630V	10%	226343300
C2	ESTF	0.01	400V	10%	222341000
C4	CERM	3300p	500V	+50% -25%	241333300
C5	CERM	3300p	500V	+50% -25%	241333300
C6	CERM	22p	500V	+50% -25%	241312200
C8	TAND	220	10V	20%	265482200
C9	ESTM	0.47	100V	10%	225454700
C10	ESTM	0.47	100V	10%	225454700
C12	ESTM	2.2	63V	10%	225162200
C14	TAND	1	100V	10%	225461000
C15	CERM	100p	500V	+50% -25%	241321000
D3	BZY88	3.3V	0.4W	5%	300521860
D4	BZY88	5.6V	0.4W	5%	300521450
D5	IN4739A	9.1V			300525410
D6	IN4739A	9.1V			300525410
D7	BZY 88	5.6V	0.4W	±5	300521450
D8	SD3				300522160
D9 to D12	IN3595				300523590
IC1	LM318H				510090210
IC2	RMS Module Intronics R310				550000840
RLT	Relay Reed				300651030
RV1	CMPM	500	3/4W	±20	130625000
RV2	CMPM	500	3/4W	±20	130625000
RV5	CMPM	20k	3/4W	±20	130642000
TR1	U235				300553810
TR2	BC107				300553320
TR3	BC107				300553320

Component Parts List

for

Printed Circuit Board A2009046

(Display)

Cct. Ref.	General Description				Solartron Part No.
R1 to R4	MEOX	68k	1/2W	5%	193546800
R5	CACP	1M	1/8W	10%	172061000

Cct Ref.	General Description	Solartron Part No.
D1	Zener 6.8V	300522540
D14	SD3	300522160
D15 to D18	1S020	300520670
TR1	BC107S	300553320
TR2	BC107S	300553320
TR3	SM6526	300552990
TR4	SM6526	300552990
TR5	BFY50	300553610
Ceramic Spacer	(R1)	470120100
Ceramic Spacer	(D15 to D18)	470111080

Component Parts List
for
Printed Circuit Board A2009023
(Range and Mode Switches)

Cct Ref.	General Description	Solartron Part No.
SWA	7-Way Switch Assembly	379600301
SWB	3-Way Switch Assembly	379600201

Component Parts List
for
Printed Circuit Board A2009025
(Local-Remote; Sample Rate: Filter Switches)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	1k	1/8W	±10%	172031000
C1	CERM	.01	25V	+50% -25%	241941000
SWC	2-Way Switch Assembly				379600101
SWD	2-Way Switch Assembly				379600401
SWE	2-Way Switch Assembly				379600101

Component Parts List
for
Printed Circuit Board A2009026
(Reed Relay: Input Filter: Feedback)

Cct Ref.	General Description				Solartron Part No.
R1	MEFM	10k	1/2W	1%	198641002
R2	MEFM	10k	1/2W	1%	198641002
R3	MEFM	10k	1/2W	1%	198641002
R4	CACP	220	1/8W	10%	172022200
R5 to R10	PRWW	Matched Set			169600401
R11	CACP	220	1/8W	10%	172022200
R12	CACP	220	1/8W	10%	172022200
RV1 to RV4		100	3/4W	10%	110016040
LP1	HIVAC A243				300720430
C1	STYR	2200p	350V	2½%	208100124
C2	CARB	0.68	100V	10%	208900001
C3	CARB	2.2	100V	10%	208900002
C4	CARB	0.022	400V	10%	208900003
C5	STYR	100p	125V	5%	208100070
C6	CERM	0.7-3.3p			290030040
RLA1					379602601
RLA2					379602601
RLB1					379602601
RLB2					379602601
RLD1					379602601
RLD2					379602601
RLE1					379602601
RLE2					379602601
RLF1					379602601
RLF2					379602601
RLH1					379602601
RLH2					379602601
RLJ1					379602601
RLJ2					379602601
RLK1					379602601
RLK2					379602601

Component Parts List
for
Fan Out Main Assembly

Cct Ref.	General Description	Solartron Part No.
SKT1	50-Way Conn. Shell Fixed	354002330

Component Parts List
for
Printed Circuit Board A2049027
(Fan Out, Main Board)

Cct Ref.	General Description				Solartron Part No.
R1 to R18	CACP	5.6kΩ	1/8W	10%	172035600
IC1	SN7475N				510000350
IC2	SN7483N				510000841
IC3	SN15862N				510000200
IC4	SN15836N				510000290
IC5	SN15846N				510000160
IC6	SN15846N				510000160
IC7	SN15862N				510000200
IC8 to IC10	SN7407N				510000750

Component Parts List
for
Printed Circuit Board A2049028
(Fan Out, Sub Board)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	82k	1/8W	10%	172048200
R2	CACP	1k	1/8W	10%	172031000
R3	MEFM	33k	1/8W	1%	192743302
R4	CACP	4.7k	1/8W	10%	172034700
R5	CACP	10k	1/8W	10%	172041000
R6	CACP	3.3k	1/8W	10%	172033300
R7	CACP	1.8k	1/8W	10%	172031800
R8	CACP	5.6k	1/8W	10%	172035600
R9	CACP	10k	1/8W	10%	172041000
R10	MEOX	390k	1/8W	10%	195453900
R11	CACP	5.6k	1/8W	10%	172035600
R12	CACP	100	1/8W	10%	172021000
R13		1k	1/8W	10%	172031000
R14		1k	1/8W	10%	172031000
R15		470	1/8W	10%	172024700
C1	ESTM	0.068	100V	10%	225446800
C2	CERM	2200p	500V	25%	208450065
C3	ESTM	0.47	160V	2%	220154700
C4	TAND	2.2	20V	20%	265862200
C5	CERM	0.01	25V	20%	241941000

Component Parts List
for
Printed Circuit Board A2009015
(A.C. Auxiliary, A203 and A223)

Cct Ref.	General Description				Solartron Part No.
R1	MEFM	990k	2W	0.1%	169600501
R2	MEFM	11k	1/4W	0.1%	198141104
R3	MEFM	100k	1/4W	1%	198351002
R4	MEFM	9.1k	1/4W	1%	198339102
R5	MEFM	1.1k	1/4W	0.1%	198131104
R6	MEOX		1W	5%	193422200
R7	PRWW	10.95k	1/4W	0.1%	169600901
R8	MEFM	33k	1/4W	1%	198343302
R9	CACP	150	1/4W	10%	172321500
R10	CACP	150	1/4W	10%	172321500
RV1	CMPM	20k	1/2W	10%	124042000
RV2	CMPM	2k	1/2W	10%	124032000
RV3		100	1/8W	10%	110016040
C1	MICA	680p	350V	5%	250326800
C3	MICA	6800 p	350V	5%	250336800
C4	CERM	0.1	30V	+50% −25%	242051000
C5	CERM	0.1	30V	+50% −25%	242051000
C6	OXLEY	0.5-5p	2kV		290060060
C7	OXLEY	0.5-5p	2kV		290060060
C8	TAND	100	20V	20%	265881000
C9	TAND	100	20V	20%	265881000
D1 to D4	SD3				300522160
D5	Zener	5.1V			300521310
IC1	SM7407				510000750
IC2	946				510000160
IC3	SN7406N				510000760
RLR	4 Pole				301201401
RLS	2 Pole				301200203
RLU	2 Pole				301200605
RLV	2 Pole				301200605

Component Parts List
for
Printed Circuit Board A2009016
(Ohms and A.C. Filter, A203 and A223)

Cct Ref.	General Description				Solartron Part No.
R1 and R4		50k	Matched Set		169600602
R2	MEFM	36k	1/4W	1%	198343602
R3	MEFM	36k	1/4W	1%	198343602
R5	MEFM	2.2M	1/4W	1%	198362202
R6	MEFM	680k	1/8W	0.5%	192756802
R7	MEOX	8.2k	1/4k	1%	195638200
R8	PRWW	10k	1/4W	0.05%	169600801
R10	MEFM	22k	1/8W	0.5%	192742202
R11	MEFM	22k	1/4W	1%	198342202
R12	MEOX	47k	1/4W	5%	195644700
R13	MEOX	820	1/4W	5%	195628200
R14	MEFM	22k	1/2W	1%	198642202
R15	MEFM	18k	1/8W	0.5%	192741802
R16	CACP	100	1/8W	10%	172021000
R17	CACP	1k	1/8W	10%	172031000
R18	MEOX	220	1/4W	5%	195622200
R19	MEOX	220	1/4W	5%	195622200
R20	MEOX	8.2k	1/4k	5%	195638200
R21	MEFM	1k	1/8W	0.5%	192731002
RV1	WWPM	1k	1/2W	10%	121231000
RV2	WWPM	1k	1/2W	10%	121231000

Cct Ref.	General Description				Solartron Part No.
C1	CARB	2.2	100V	10%	208900002
C2	CARB	2.2	100V	10%	208900002
C3	ESTM	6.8	100V	10%	225466800
C4	ESTM	6.8	100V	10%	225466800
C5	ESTM	1.5	100V	10%	225461500
C6	ESTM	1.5	100V	10%	225461500
C7	ESTM	3.3	100V	10%	225463300
C8	ESTM	3.3	100V	10%	225463300
C9	CERM	0.1	30V	+50% −25%	242051000
C10	CERM	0.1	30V	+50% −25%	242051000
C11	CERM	220p	500V	20%	241322200
C12	STYR	33p	125V	10%	210213300
D1 to D3	SD3				300522160
D4	1N3595				300523590
D5	1N3595				300523590
D7	SD3				300522160
D8	1N4004				300522070
D9	1N3595				300523590
D10	1N3595				300523590
D11 to D13	SD3				300522160
D14	BAY72				300524530
D16	1N3595				300523590
TR1	RCA40327				300552890
Spreader Pads					300584340
IC1	SL13348				510090080
IC2	741C				510000591
RLM	4 Pole				300651860
RLN	4 Pole				301201102
RLP	4 Pole				301201102

Component Parts List
for
Printed Circuit Board A2009022
(Power Supply, Stabiliser Board)

Cct Ref.	General Description				Solartron Part No.
R1	POWW	0.22	2.6W	10%	173500220
R4	CACP	22k	1/4W	10%	172342200
R5	CACP	1k	1/4W	10%	172331000
R6	CACP	10k	1/4W	10%	172341000
R7	CACP	2.2k	1/4W	10%	172332200
R8	CACP	2.2k	1/4W	10%	172332200
R9	CACP	470	1/4W	10%	172324700
R12	MEFM	4.7k	1/8W	0.5%	192734702
R13	MEFM	2.2k	1/8W	0.5%	192732202
R14	CACP	2.2k	1/8W	10%	172032200
RV1	WWPM	1k	1/2W	10%	121231000
C1	CERM	0.1	30V	+50% −25%	242051000
C2	CERM	0.1	30V	+50% −25%	242051000
C3	CERM	470	500V	20%	241324700
C11	ALME	4700	40V		273894700
C12	TAND	2.2	20V	20%	265862200

Cct Ref.	General Description	Solartron Part No.
T1	Timing	309600501
T2	Inverter	309600303
	Board for T2	A2009024
TR6	BDX35	300555230
TR7	BDX35	300555230
TR8	2N2218A	300552000
TR9	2N2053	300551800

Component Parts List
for
Printed Circuit Board A2009013
(Earthy Mother Board)

Cct Ref.	General Description	Solartron Part No.
SKT1 to SK3	Connector 24-24 PWC	352524250
SKT4	Connector 16-16 PWC	352516280
SKT5	Connector 32-32 PWC	352532290
SKT6	Connector 44-WAY	352544060
	Polarizing Key	354003791

Component Parts List
for
Printed Circuit Board A2009014
(A.C. Converter, A203 and A223)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	10M	1/2W	5%	170871000
R2	POWW	15k	3W	5%	173741500
R3	MEOX	3.9k	1/4W	5%	195633900
R4	MEOX	1k	1/4W	5%	195631000
R5	CACP	3.9k	1/8W	10%	172033900
R6	MEOX	3.9k	1/4W	5%	195633900
R7	MEOX	1k	1/4W	5%	195631000
R8	CACP	3.9k	1/8W	10%	172033900
R9	CACP	1.5k	1/8W	10%	172031500
R10	CACP	3.3k	1/8W	10%	172033300
R11	CACP	330	1/8W	10%	172023300
R12	CACP	270	1/8W	10%	172022700
R13	CACP	10M	1/4W	10%	172371000
R14	CACP	1k	1/2W	10%	172031000
R15	CACP	10k	1/8W	10%	172041000
R16	CACP	3.9k	1/8W	10%	172033900
R17	CACP	39	1/8W	10%	172013900
R18	CACP	390	1/8W	10%	172023900
R19	MEOX	3.9k	1/2W	5%	193533900
R20	MEOX	180	1/4W	5%	195621800
R21	MEOX	330	1/4W	5%	195623300
R22 to R25			Set of 4		169601201
R26	MEFM	1.5	1/8W	1%	191201502
R27	MEFM	15k	1/8W	0.5%	192741502
R28	CACP	10	1/8W	10%	172011000
R29 and R31		47.67k	Set of 2		169601001
R30	MEFM	12.5k	1/4W	1%	198141251
R32	CACP	10	1/8W	10%	172011000
R33	POWW	15k	3W	5%	173741500
R34	CACP	1.5k	1/8W	10%	172031500
R36	MEOX	120k	1/4W	5%	195651200
R37	MEOX	1k	1/4W	5%	195631000
R38	MEOX	1k	1/4W	5%	195631000
R39	MEOX	120k	1/4W	5%	195651200

Cct Ref.	General Description				Solartron Part No.
RV1	CMPM	100	1/8W	10%	110016040
RV2	CMPM	2000	1/4W	10%	124032000
RV3	CAPS	2200	1/2W	20%	137332200
C1		0.033	630V	20%	226443300
C2	ESTF	4700p	160V	10%	221334700
C3	CERM	0.047	25V	+50% −25%	241944700
C4	ESTF	4700p	160V	10%	221334700
C5	ESTF	3300p	160V	10%	221333300
C6	TAND	2.2	20V	20%	265862200
C7	CERM	82p	500V	20%	241518200
C8	CERM	15p	500V	20%	241311500
C9	CERM	0.1	30V	+50% −25%	242051000
C10	ESTM	0.68	100V	10%	225456800
C11	ESTM	0.1	100V	10%	225451000
C12	CERM	0.1	30V	+50% −25%	242051000
C13	ESTM	1.0	100V	10%	225461000
C14	ESTM	1.0	100V	10%	225461000
C15	CERM	33p	500V	20%	241313300
C16	CERM	330p	500V	20%	241323300
C17	CERM	4.7p	500V	20%	241304700
C18	CERM	4.7p	500V	20%	241304700
L1	FX1115				309010060
D1	Zener	7.5V			300521460
D2	IN3595				300523590
D3	Zener	5.6V			300521450
D4	IN3595				300523590
D5	Zener	5.6V			300521450
D6	Zener	7.5V			300521460
D7	SD3				300522160
D8	SD3				300522160
D9	Zener	6.2V			300521240
D10	SD3				300522160
D11	SD3				300522160
D12	Zener	3.9V			300521420
D13	Zener	3.9V			300521420
D14	5082—2800	Hewlett	Packard		300524910
D15	5082—2800	Hewlett	Packard		300524910
D16	SD3				300522160
TR1					300553810
TR2 to TR4	BC107S				300553320
TR5	SM6526				300552990
TR6	BC107S				300553320
IC1	709C				510000250
RLT	2 Pole:	P.C.B. Type: (Silenced)			301200401
Ceramic Spacers					470120100
Aluminium Screen					A2000205
Tubular Spacers					

Component Parts List
for
Printed Circuit Board A2009010
(Range and Mode Logic)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	33k	1/8W	10%	172043300
C1	TAND	47μ	6V	20%	265274700
IC1	SN15862N				510000200
IC2	SN15836N				510000290
IC3	SN15862N				510000200
IC4	SN15846N				510000160
IC5	SN15846N				510000160
IC6	SN15846N				510000160
IC7	SN15862N				510000200
IC8	SN15846N				510000160
IC9	SN15846N				510000160
IC10	SN158093N				510000300
IC11	SN158093N				510000300
IC12	SN74121N				510000530
IC13	SN15846N				510000160
IC14	SN7407N				510000750
IC15	SN15846N				510000160
IC16	SN15862N				510000200

Component Parts List
for
Printed Circuit Board A2209010
(Range and Mode Logic)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	33k	1/8W	10%	172043300
C1	TAND	47	6V	20%	265274700
IC1	SN15846N				510000160
IC2	SN15846N				510000160
IC3	SN15836N				510000290
IC4	SN15862N				510000200
IC5	SN15862N				510000200
IC6	SN15846N				510000160
IC7	SN7407N				510000750
IC8	SN158093N				510000300
IC9	SN15846N				510000160
IC10	SN74121N				510000530

Component Parts List
for
Printed Circuit Board A2009011
(Counter Logic)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	2.2k	1/8W	10%	172032200
R2	CACP	2.2k	1/8W	10%	172032200
D1 to D5	SD3				300522160
IC1	SN7406N				510000760
IC2	SN15830N				510000100
IC3	SN158093N				510000300
IC4	SN7475N				510000350
IC5	SN7490N				510000280
IC6	SN7475N				510000350
IC7	SN7490N				510000280
IC8	SN7475N				510000350
IC9	SN7490N				510000280
IC10	SN7475N				510000350
IC11	SN7490N				510000280
IC12	SN7475N				510000350
IC13	SN15862N				510000200
IC14	SN7475N				510000350
IC15	SN15862N				510000200
IC16	SN15846N				510000160
IC17	SN15846N				510000160
IC18	SN15846N				510000160

Component Parts List
for
Printed Circuit Board A2009012
(Power Supply Inverter Board)

Cct Ref.	General Description				Solartron Part No.
R2	MEOX	150	1W	5%	193421500
R3	MEOX	47	1W	5%	193414700
R11	CACP	1.5k	1/4W	10%	172331500
R15	CACP	10	1/8W	10%	172011000
R16	CACP	220k	1/8W	10%	172052200
R17	MEOX	150	1W	5%	193421500
R18	CACP	220k	1/8W	10%	172052200
R19	CACP	10	1/8W	10%	172011000
R20	CACP	2.2	1/4W	10%	172302200
R21	CACP	2.2	1/4W	10%	172302200
R22	CACP	680	1/4W	10%	172326800
R23	CACP	2.2k	1/4W	10%	172332200
C4		6800p	500V		241036800
C5	TAND	47	35V	20%	266074700
C6	ALME	5	150V	+50% −10%	271665000
C7	ALME	5	150V	+50% −10%	271665000
C8	TAND	15	20V	20%	265871500
C9	TAND	15	20V	20%	265871500
C10		200	10V	+50% −10%	273182200
C13	CERM	470	500V	20%	241324700
C14	CERM	0.01	25V	+50% −20%	241941000
C15	CERM	0.01	25V	+50% −20%	241941000
C16	CERM	0.047	25V	+50% −20%	241944700
C17	TAND	15	20V	20%	265871500
L3		68		10%	305020370
L4		68		10%	305020370
L5		300			309500101
L6	FX1115				309010060
L7	FX1115				309010060
D2 to D5	BA148				300525070
D6	1N4933				300524830
D7	1N4933				300524830
D8 to D13	BAY 72				300524530
D19	BAY 72				300524530
D20	BAY 72				300524530

Cct Ref.	General Description				Solartron Part No.
C1	ESTF	1000p	400V	10%	222331000
C2	ESTF	1000p	400V	10%	222331000
C3	ESTM	1	100V	10%	225461000
C4	ESTM	0.047	100V	10%	225444700
C5	ESTM	0.1	100V	10%	225451000
*C6	STYR	18p	125V	10%	210211800
C7	CERM	0.1	30V	+50% −25%	242051000
*C8	STYR	150p	500V	1%	210321500
C9	CERM	3300p	500V	20%	241333300
C10	ESTM	0.047	100V	10%	225444700
C11	CERM	100p	500V	20%	241321000
C12	CERM	100p	500V	20%	241321000
C13	TAND	22	15V	20%	265672200
C14	TAND	22	15V	20%	265672200
C15	CERM	0.01	25V	+50% −25%	241941000
C16	CERM	0.01	25V	+50% −25%	241941000
C17	TAND	22	15V	20%	265672200
D1	SD3				300522160
D2	SD3				300522160
D3	Zener	2.7V			300523870
D4	IN3595				300523590
D5	IN3595				300523590
D6	Zener	6.2V			300521240
D7	SD3				300522160
D8	SD3				300522160
D9 to D22	SD3				300522160
D23	9.1V				300521340
TR1	BFX37				300553030
TR2	2N2484				300552860
TR3	U1899E				300554320
TR4	SM6526				300552990
TR5	BC107S				300553320
TR6	SM6526				300552990
TR7	BC107S				300553320
TR8	BC107S				300553320
TR9	A1672				300551910
TR10	A1672				300551910
TR11	BC107S				300553320
TR12	BC107S				300553320
TR13	ZN2484				300552860
IC1	SN15836N				510000290
IC2	SN15862N				510000200
T1					309600101

* For 60Hz, values are as follows

C6	10p	210211000
C8	100p	210321000

Component Parts List for Printed Circuit Board A2209008 (Control Discrete Circuits)

Cct Ref.	General Description				Solartron Part No.
R13	CACP	4.7k	1/8W	10%	172034700
R14	CACP	1k	1/8W	10%	172031000
R15	CACP	1k	1/8W	10%	172031000
R16	CACP	4.7k	1/4W	10%	172334700
R17	CACP	4.7k	1/4W	10%	172334700
R18	CACP	18k	1/8W	10%	172041800
R19	CACP	1k	1/8W	10%	172031000
R20	CACP	4.7k	1/8W	10%	172034700
R21	CACP	4.7k	1/8W	10%	172034700
R22	CACP	2.2k	1/8W	10%	172032200
R23	CACP	1k	1/8W	10%	172031000
R24	CACP	3.3k	1/4W	10%	172333300
R25	CACP	3.3k	1/4W	10%	172333300
R31	CACP	1k	1/8W	10%	172031000
R33	CACP	1k	1/8W	10%	172031000
R34	CACP	1k	1/4W	10%	172331000
R35	CACP	100	1/8W	10%	172021000
*C8	STYR	150p	500V	1%	210321500
C9	CERM	3300p	500V	20%	241333300
C10	ESTM	0.047	100V	10%	225444700
C11	CERM	100p	500V	20%	241321000
C12	CERM	100p	500V	20%	241321000
C13	TAND	22	15V	20%	265672200
C14	TAND	22	15V	20%	265672200
C15	CERM	0.01	25V	+50% −20%	241941000
C17	TAND	22	15V	20%	265672200
D7 to D22	SD3				300522160
D23	Zener	9.1V			300521340
TR6	SM6526				300552990
TR7	BC107S				300553320
TR8	BC107S				300553320
TR9	2N2369				300552390
TR10	2N2369				300552390
TR11	BC107S				300553320
TR12	BC107S				300553320
TR13	ZN2484				300552860
IC1	SN15836N				510000290
IC2	SN15862N				510000200
T1	Oscillator Coil				309600101

* For 60Hz, value is changed as follows:-

C8	100p	210321000

Component Parts List for Printed Circuit Board A2009009 (Control Logic)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	1k	¼W	10%	172331000
R2	CACP	1k	¼W	10%	172331000
D1	SD3				300522160
IC1 to IC3	SN15846N				510000160
IC4	SN15830N				510000100
IC5	SN15846N				510000160
IC6	SN7490N				510000280
IC7 to IC11	SN15846N				510000160
IC12	SN158093N				510000300
IC13	SN158093N				510000300
IC14	SN7474				510000490
IC15	SN15836N				510000290
IC16	SN15862N				510000200

Component Parts List
for
Printed Circuit Board A2009006
(Floating Mother Board, A200 and A203)

Cct Ref.	General Description				Solartron Part No.
R1 to R4	2.475M	Matched Set			169602401
R5	100k				
R6	MEOX	3.3k	1/4W	5%	195633300
R7	MEOX	3.3k	1/4W	5%	195633300
R8	MEOX	220	1/16W	1%	192622202
RV1	WWPM	200	0.75W	10%	122022000
RV2	WWPM	20k			121242000
C1	CERM	470p	500V	20%	241324700
D1	Zener	C3V3	3.3V	5%	300521860
D2	Zener	C4V7	4.7V	5%	300521470
SKT A					352516280
SKT B					352516280
SKT D					352516280
SKT E					352516280
SKT F					352524250
SKT H					352516280
RLL	Relay VP4 (Silenced)				301200701
Polarizing Key					354003791
Pivot Moulding					A2000090

Component Parts List
for
Printed Circuit Board A2209006
(Floating Mother Board, A220 and A223)

Cct Ref.	General Description		Solartron Part No.
R1 to R4	2.475M	Matched Set	169602401
R5	99.95k		

All other components as per A200 and A203 Floating Mother Board Parts List.

Component Parts List
for
Printed Circuit Board A2009007
(Display)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	39k	¼W	10%	172343900
R2 to R6	CACP	22k	¼W	10%	172342200
R7	CACP	68k	¼W	10%	172346800
R8 to R10	CACP	4.7k	1/8W	10%	172034700
R11	CACP	220	1/8W	10%	172022200
R12 to R16	CACP	4.7k	1/8W	10%	172034700
R17	CACP	1.8k	1/8W	10%	172031800
R18	CACP	56k	¼W	10%	172345600
R19 to R23	CACP	1.8k	1/8W	10%	172031800
R24	CACP	4.7k	1/8W	10%	172034700
R25 to R27	CACP	12k	1/8W	10%	172041200
R28	CACP	56k	¼W	10%	172345600
R29	CACP	56k	¼W	10%	172345600
D1 to D9	SD3				300522160
D10	Zener	2.7V			300523870
D11	SD3				300522160
TR1 to TR12	A1778				300551430
TR13	40327				300552890
TR14	40327				300552890
TR15	A1778				300551430
IC1 to IC4	SN74141N				510000471
ILP1 to ILP5	Neon Indicator 16H/5				300720300
V1	Numicator ZM1263				300011411
V2 to V6	Numicator ZM1175				300011400
V7	Neon Indicator 16H/5				300720300

Component Parts List
for
Printed Circuit Board A2009008
(Control Discrete Circuit)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	1k	1/8W	10%	172031000
R2	CACP	2.2k	1/8W	10%	172032200
R3	CACP	1M	1/8W	10%	172061000
R4	CACP	1M	1/8W	10%	172061000
R5	CACP	100k	1/8W	10%	172051000
R6	CACP	1k	1/8W	10%	172031000
R7	CACP	10k	1/8W	10%	172041000
R8	CACP	470	1/8W	10%	172024700
R9	CACP	1k	1/8W	10%	172031000
R10	CACP	33k	1/8W	10%	172043300
R11	CACP	3.3k	1/8W	10%	172033300
R12	CACP	100k	1/8W	10%	172051000
R13	CACP	4.7k	1/8W	10%	172034700
R14	CACP	1k	1/8W	10%	172031000
R15	CACP	1k	1/8W	10%	172031000
R16	CACP	4.7k	1/4W	10%	172334700
R17	CACP	4.7k	1/4W	10%	172334700
R18	CACP	18k	1/8W	10%	172041800
R19	CACP	1k	1/8W	10%	172031000
R20	CACP	4.7k	1/8W	10%	172034700
R21	CACP	4.7k	1/8W	10%	172034700
R22	CACP	2.2k	1/8W	10%	172032200
R23	CACP	1k	1/8W	10%	172031000
R24	CACP	3.3k	1/4W	10%	172333300
R25	CACP	3.3k	1/4W	10%	172333300
R31	CACP	1k	1/8W	10%	172031000
R33	CACP	1k	1/8W	10%	172031000
R35	CACP	100	1/8W	10%	172021000

Cct Ref.	General Description		Solartron Part No.
D3 to D7	1N3595		300523590
D8	SD3		300522160
D9	BZY88	C4V3	300523900
D10	BZY88	C4V3	300523900
D11	BZY88	C6V2	300521240
D12	BZY88	C12	300521480
D13	SD3		300522160
D14	SD3		300522160
TR3	U1899E		300554320
TR4	U1897E		300553800
TR5 to TR9	U1897E		300553800
TR10	U235		300553810
TR11	2N2369		300552390
IC1	A747C		510090020
IC2	741C		510000591
IC3	710C		510000241
Spreader Pad			300584340
Ceramic Spacer			470120100

Component Parts List
for
Printed Circuit Board A2009004
(Logic and Toroid Drivers)

Cct Ref.	General Description				Solartron Part No.
R1 to R5	CACP	1k	1/4W	10%	172331000
R7	CACP	4.7k	1/4W	10%	172334700
R9	CACP	15k	1/4W	10%	172341500
R10	CACP	4.7k	1/4W	10%	172334700
R11	CACP	15k	1/4W	10%	172341500
R12	CACP	4.7k	1/4W	10%	172334700
R14	MEOX	180	1W	5%	193421800
R17	CACP	1k	1/4W	10%	172331000
R18 to R20	CACP	1k	1/8W	10%	172031000
R21	CACP	2.2k	1/8W	10%	172032200
R23	CACP	2.2k	1/8W	10%	172032200
R24	CACP	120	1/4W	10%	172321200
C1	TAND	1	25V	+100% −20%	266061000
C2	ALME	200	10V	+50% −10%	273182200
C3	TAND	100	10V	20%	265481000
D1 to D8	SD3				300522160
D10	1N4733A				300524370
D11	SD3				300522160
TR1 to TR5	2N2369				300552390
TR7	A1778				300551430
IC1	SN15846N				510000160
IC2	SN7474N				510000490
IC3	SN15846N				510000160
IC4	SN15862N				510000200
IC5	SN15846N				510000160
IC6	SN15846N				510000160

Component Parts List
for
Printed Circuit Board A2009005
(Floating Power Supply and F.E.T. Drivers)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	22	1/8W	10%	172012200
R2	CACP	22	1/8W	10%	172012200
R3	CACP	12k	1/8W	10%	172041200
R4	CACP	2.2k	1/8W	10%	172032200
R5 to R7	CACP	1k	1/8W	10%	172031000
R8	CACP	10k	1/8W	10%	172041000
R9	CACP	12k	1/8W	10%	172041200
R10	CACP	2.2k	1/8W	10%	172032200
R11	CACP	1k	1/8W	10%	172031000
R12	CACP	1k	1/8W	10%	172031000
R13	CACP	10k	1/8W	10%	172041000
R14	CACP	12k	1/8W	10%	172041200
R15	CACP	2.2k	1/8W	10%	172032200
R16	CACP	1k	1/8W	10%	172031000
R17	CACP	1k	1/8W	10%	172031000
R18	CACP	10k	1/8W	10%	172041000
R19	CACP	2.2k	1/8W	10%	172032200
R20	CACP	47k	1/8W	10%	172044700
R21	CACP	10k	1/8W	10%	172041000
R22	CACP	1.5k	1/8W	10%	172031500
R23	CACP	1k	1/8W	10%	172031000
R24	CACP	680	1/8W	10%	172026800
R25	CACP	33k	1/8W	10%	172043300
R26	CACP	33k	1/8W	10%	172043300
C1 to C4	CERM	33p	500V	20%	241313300
C6	TAND	47	35V	20%	266074700
C7	TAND	15	20V	20%	265871500
C8	TAND	15	20V	20%	265871500
C9	TAND	47	35V	20%	266074700
C10	TAND	100	20V	20%	265881000
C12	TAND	100	20V	20%	265881000
C13	TAND	100	20V	20%	265881000
L1 to L3		68		10%	305020370
D1	SD3				300522160
D2	SD3				300522160
D4	BAY 72				300524530
D5	BAY 72				300524530
D6 to D11	BAY 72				300524530
D12	Zener	2.7V			300523870
D13	Zener	2.7V			300523870
TR1	2N2369				300552390
TR2	BCY70				300553590
TR3	2N2369				300552390
TR4	BCY70				300553590
TR5	2N2369				300552390
TR6	BCY70				300553590
TR7	BCY70				300553590
TR8	BC1075				300553320
TR9	BC107				300553320

Component Parts List
for
Printed Circuit Board A2209002
(Input Amplifier, A220 and A223)

Cct Ref.	General Description				Solartron Part No.
R1	CACP	220k	1/8W	10%	172052200
R2	CACP	470	1/8W	10%	172024700
R3	CACP	10k	1/8W	10%	172041000
R4	CACP	100k	1/8W	10%	172051000
R5	CACP	220k	1/8W	10%	172052200
R6	CACP	39	1/8W	10%	172013900
R7	CACP	220k	1/8W	10%	172052200
R8	CACP	10k	1/8W	10%	172041000
R9	CACP	68k	1/8W	10%	172046800
R10	CACP	330	1/8W	10%	172023300
R11	CACP	330	1/8W	10%	172023300
R12	CACP	10k	1/8W	10%	172041000
R13	CACP	10k	1/8W	10%	172041000
R14	CACP	22k	1/8W	10%	172042200
R15	CACP	22k	1/8W	10%	172042200
R16	CACP	3.3k	1/8W	10%	172033300
R17	CACP	3.3k	1/8W	10%	172033300
R18	CACP	10k	1/8W	10%	172041000
R19	CACP	10k	1/8W	10%	172041000
R20	CACP	33k	1/8W	10%	172043300
R21	CACP	220k	1/8W	10%	172052200
R22	CACP	100k	1/8W	10%	172051000
R23	MEFM	10	1/16W	1%	192611002
R25	CACP	220k	1/8W	10%	172052200
R26	CACP	470	1/8W	10%	172024700
R27	CACP	100	1/8W	10%	172021000
RV1	WWPM	20k	1/2W	10%	121242000
C1	ESTM	0.47	100V	10%	225454700
C2	ESTM	0.047	100V	10%	225444700
C3	ESTM	0.047	100V	10%	225444700
C4	ALME	200	10V	20%	273182200
C6	ESTM	0.47	100V	10%	225454700
C7	TAND	47	20V	20%	265874700
C8	CERM	0.047	25V	20%	241944700
C10	ESTM	1	100V	10%	225461000
C11	ALME	47	40V	+100% -20%	273774700
C12	ALME	47	40V	+100% -20%	273774700
C13	CERM	1000p	500V	20%	241331000
C14	ESTM	0.047	100V	10%	225444700
C15	ESTM	0.047	100V	10%	225444700
C16	CERM	3.3p	700V		240203300
C17	STYR	100p	125V	10%	210221000
D1 to D4	1N3595				300523590
D5	SD3				300522160
D6	SD3				300522160
D7	Zener	3.9V			300521420
D8	Zener	3.9V			300521420
D10	Zener	25V			300525090
D11	Zener	25V			300525090
D12	Zener	13V			300523920
D13	Zener	13V			300523920
TR1	40673				300555210
TR2	40673				300555210
TR3	BC107/S				300553320
TR4	BC107/S				300553320
IC1	SC9496G				510090030
IC2	LM301A				510000620

Component Parts List
for
Printed Circuit Board A2009003
(Integrator and Reference)

Cct Ref.	General Description				Solartron Part No.
R3	MEFM	820	1/8W	.5%	192728202
R4	MEFM	180k	1/8W	.5%	192751802
R5	MEFM	150k	1/8W	.5%	192751502
R6	MEFM	1.5k	1/8W	.5%	192731502
R7	MEFM	1.5k	1/8W	.5%	192731502
R8	MEFM	82k	1/8W	.5%	192748202
R9	CACP	56	1/8W	10%	172015600
R10	MEFM	12k	1/8W	.5%	192741202
R11	MEFM	12k	1/8W	.5%	192741202
R12	MEFM	10	1/8W	.5%	192711002
R18	CACP	47k	1/8W	10%	172044700
R20	CACP	47	1/8W	10%	172014700
R21	CACP	56	1/8W	10%	172015600
R22	CACP	2.2k	1/8W	10%	172032200
R23	CACP	15k	1/8W	10%	172041500
R24	CACP	15k	1/8W	10%	172041500
R25	CACP	10	1/8W	10%	172011000
R26	CACP	470	1/8W	10%	172024700
R27	CACP	1k	1/4W	10%	172331000
R28	CACP	1k	1/8W	10%	172031000
R29	CACP	15k	1/8W	10%	172041500
R30	CACP	1k	1/8W	10%	172031000
R32	CACP	220	1/4W	10%	172322200
R34	MEOX	3.9k	1/4W	5%	195633900
R35 & R36	Matched Set				169600301
R37	CACP	22M	1/4W	10%	172372200
R38 to R41 & R47	Matched Set				169600701
R42	MEFM	75	1/8W	1%	192717501
R43	MEFM	150	1/8W	.5%	192721501
R44	MEFM	300	1/8W	1%	192723001
R45	MEFM	150	1/8W	.5%	192721501
R46	MEFM	300	1/8W	1%	192723001
R48	MEFM	1.5k	1/8W	.5%	192731502
R49	MEFM	1.5k	1/8W	.5%	192731502
RV2	WWPS	5k	1/4W	5%	130535000
RV3	WWPS	5k	1/4W	5%	130535000
RV4	WWPM	20k	1/8W	10%	121242000
RV5	CMPM	100	1/8W	10%	110016040
C5 to C9	CERM	33p	500V	20%	241313300
C10	TAND	15	20V	20%	265871500
C11 to C13	CERM	0.1	30V	+50% −25%	242051000
C14	STYR	0.15	63V	10%	209951500
C15	ESTM	2.2	100V	10%	225462200
C16	TAND	15	20V	20%	265871500
C17	CERM	1000p	500V	20%	241331000
D2	IN829				300525400

Component Parts List
for
Printed Circuit Board A2009002
(Input Amplifier, A200 and A203)

Cct Ref.	General Description				Solartron Part No.
R1	MEFM	10k	1/16W	1%	192641002
R2	CACP	1M	1/8W	10%	172061000
R3	MEFM	10k	1/16W	1%	192641002
R4	MEFM	220	1/16W	1%	192622202
R5	CACP	56k	1/8W	10%	172045600
R6	MEFM	2.2k	1/16W	1%	192632202
R7	CACP	22k	1/8W	10%	172042200
R8	MEFM	2.2k	1/16W	1%	192632202
R9	CACP	470k	1/8W	10%	172054700
R10	MEFM	2.2k	1/16W	1%	192632202
R11	MEFM	10k	1/16W	1%	192641002
R12	CACP	1k	1/8W	10%	172031000
R13	CACP	1M	1/8W	10%	172061000
R14	CACP	1k	1/8W	10%	172031000
R15	MEFM	15k	1/16W	1%	192641502
R16	MEFM	220	1/16W	1%	192622202
R17	CACP	56k	1/8W	10%	172045600
R18	MEFM	10k	1/16W	1%	192641002
R19	CACP	33k	1/8W	10%	172043300
R20	CACP	6.8k	1/8W	10%	172036800
R21	CACP	10k	1/8W	10%	172041000
R22	CACP	220k	1/8W	10%	172052200
R23	CACP	33k	1/8W	10%	172043300
R24	CACP	150	1/8W	10%	172021500
R25	CACP	1.8k	1/8W	10%	172031800
R26	CACP	22k	1/8W	10%	172042200
R27	CACP	22k	1/8W	10%	172042200
R28	CACP	3.3k	1/8W	10%	172033300
R29	CACP	27k	1/8W	10%	172042700
R30	CACP	1k	1/8W	10%	172031000
R31	MEFM	82	1/16W	1%	192618202
R32	CACP	100k	1/8W	10%	172051000
R33	MEFM	470	1/16W	1%	192624702
R34	MEFM	2.2k	1/16W	1%	192632202
R35	MEFM	10k	1/16W	1%	192641002
R36	CACP	6.8k	1/8W	10%	172036800
R37 to R42	CACP	1k	1/8W	10%	172031000
R43	CACP	470	1/8W	10%	172024700
R44	CACP	470	1/8W	10%	172024700
R45	CACP	100k	1/8W	10%	172051000
R46	MEFM	10	1/16W	1%	192611002
R47	CACP	680k	1/8W	10%	172056800
R48	CACP	470	1/8W	10%	172024700
R49	CACP	470k	1/8W	10%	172054700
R50	CACP	33k	1/8W	10%	172043300
R51	CACP	68	1/8W	10%	172016800
R52	CACP	39	1/8W	10%	172013900
R53	CACP	470	1/8W	10%	172024700
R54	CACP	680k	1/8W	10%	172056800
R55	CACP	22k	1/8W	10%	172042200
R57	CACP	100	1/8W	10%	172021000
RV1	CMPM	100			110016040
RV2	WWPS	10k			130541000
C1	ESTM	0.047	100V	10%	225444700
C2	ESTM	0.047	100V	10%	225444700
C3	MICA	22p	350V	5%	250312200
C4	TAND	22	15V	20%	265672200
C5	MICA	1000p	350V	5%	250331000
C6	TAND	15	20V	20%	265871500
C7	MICA	1000p	350V	5%	250331000
C8	MICA	100p	350V	5%	250321000

Cct Ref.	General Description				Solartron Part No.
C9	TAND	47	20V	20%	265874700
C10	CERM	1000p	500V	20%	241331000
C11	MICA	470p	350V	5%	250324700
C12	ESTM	0.01	100V	10%	225441000
C13	TAND	22	15V	20%	265672200
C14	TAND	15	20V	20%	265871500
C15	TAND	15	20V	20%	265871500
C16	ESTM	0.22	100V	10%	225452200
C17	TAND	22	15V	20%	265672200
C18	CERM	33p	200V	10%	240713300
C19	CERM	33p	200V	10%	240713300
C20	ESTM	0.22	100V	10%	225452200
C21 to C23	ESTM	0.22	100V	10%	225452200
C24	ESTM	0.047	100V	10%	225444700
C25	ESTM	0.047	100V	10%	225444700
C26	ALME	50	40V	+50% −10%	273774700
C27	ALME	50	40V	+50% −10%	273774700
C28	CERM	0.047	25V	+50% −20%	241944700
C29	ESTM	0.047	100V	10%	225444700
C30	ESTM	0.047	100V	10%	225444700
D1	Zener	4.7V			300521470
D2	SD3				300522160
D3	SD3				300522160
D4	Zener	6.2V			300521240
D5	Zener	3.3V			300521860
D6	IN3595				300523590
D7	IN3595				300523590
D8	Zener	25V			300525090
D9	Zener	25V			300525090
D10	IN3595				300523590
D11	IN3595				300523590
D12	Zener	4.7V			300521470
D13	SD3				300522160
TR1	2N4303				300553160
TR2	BFX37				300553030
TR3	2N4303				300553160
TR4	BFX37				300553030
TR5	BFX37				300553030
TR6 to TR8	BC107S				300553320
TR9 to TR13	2N2369				300552390
TR14	40673				300555210
TR15	U 1897 E				300553800
TR16	U 1897 E				300553800
IC1	SC9495G				510090030
IC2	741C				510000591
Integrated Circuit Spreader Pads					300584340
Plate					A2000071
Rear Plate					A2000073
Insulating Rubber					A2000074
Chopper Box Moulding Fabrication					DA2000080